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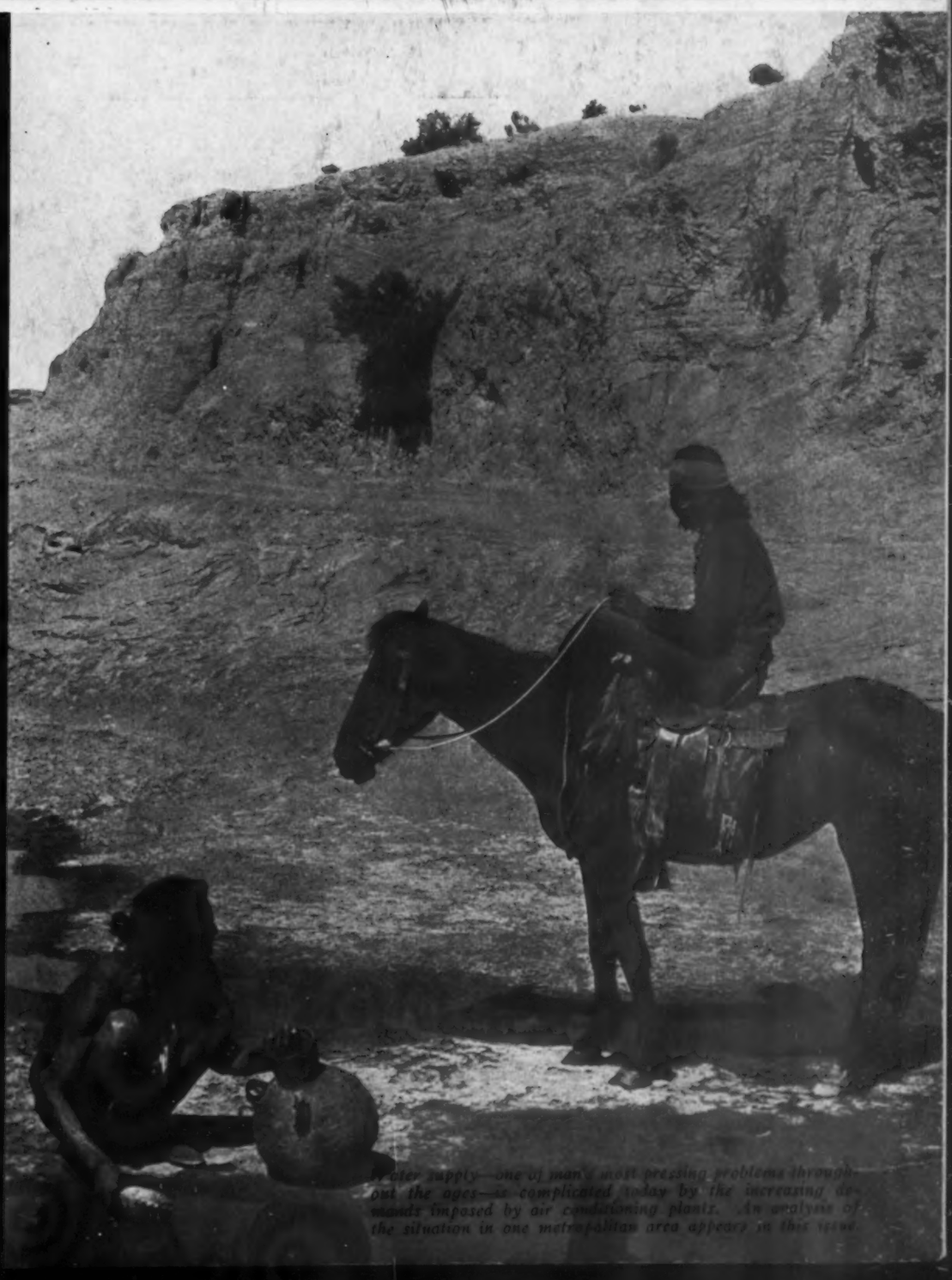
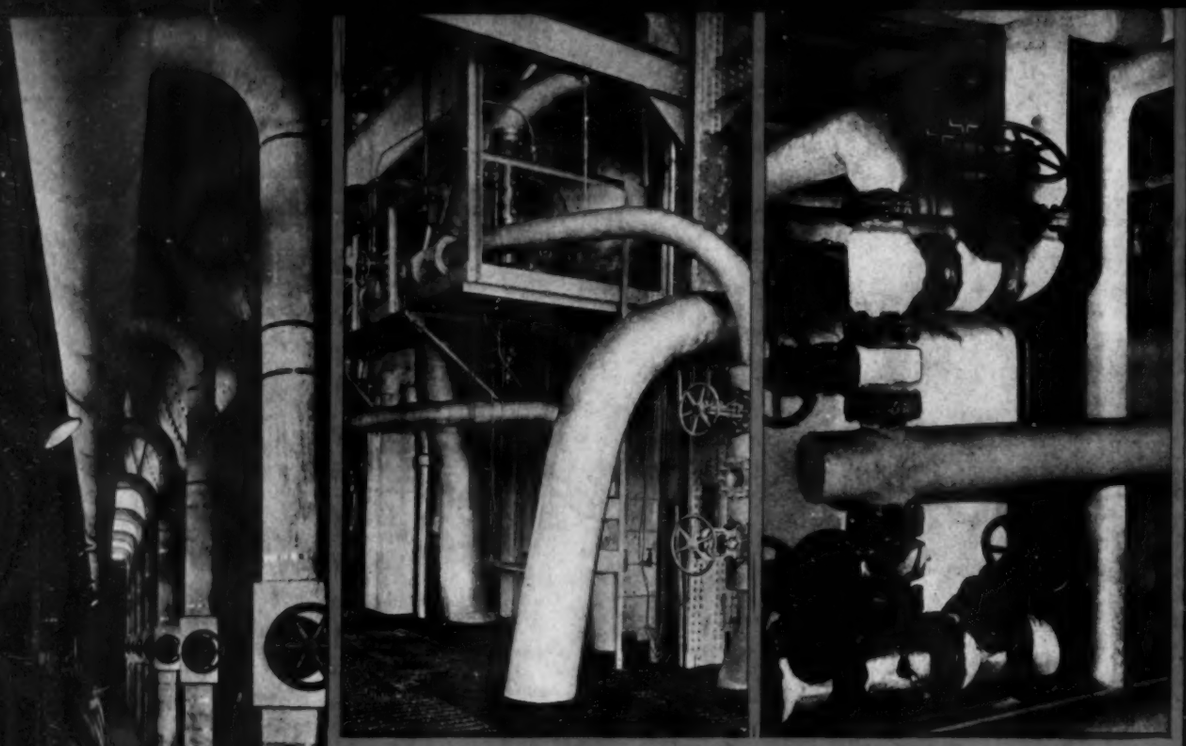
Heating · Piping and Air Conditioning



Water supply—one of man's most pressing problems throughout the ages—is complicated today by the increasing demands imposed by air conditioning plants. An analysis of the situation in one metropolitan area appears in this issue.



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THE EDITOR'S PAGE • November, 1936

■ **Patent Centennial** — A nation-wide celebration of the founding of the present American patent system in 1836 is to be held in Washington, November 23. The celebration is sponsored by the National Committee for the American Patent System Centennial, Room 5872, Department of Commerce, Washington, D. C. The committee membership includes representatives of the commerce department, the patent office, the national association of patent attorneys, science museums and industry, and is chairmanned by Dr. Charles F. Kettering, president of General Motors Research Corp. . . . A. W. Robertson, chairman, Westinghouse Electric & Mfg. Co., proposed a "100 year plan" in an address on inventions and standards of living, before the Boston Conference on Distribution, Sept. 29. He said, "Within the next few years all unhealthful air will be purified. That is, we are going to undertake to purify our air just the same as we pasteurize our milk and purify our water and food. And if it weren't for the stupendous nature of the task we would have had purified air first—and water, milk and food would have taken second place. We all breathe air some eighteen times a minute; whereas, we absorb food and water only several times a day. The crowded conditions of civilization have brought strange unhealthy situations; and one of the common evils which crowding has brought is foul air, often disease laden, which results from crowding. And we of the "golden age" will shirk our task if we do not find some way either to cure the crowding or cure the foul air."

■ **A. C. Increases Business**—According to J. J. Donovan, manager of G. E.'s air conditioning department, before the National Executives' Conference at New York last month, the average restaurant which installs air conditioning enjoys a 32 per cent increase in patronage, the average movie theater a 25 per cent increase. The current increase in railroad travel is due not alone to lower fares, but also, according to Mr. Donovan, largely to the air conditioning of modern trains. In this connection he quoted from a railroad advertisement published in 1914—"A cool, refreshing trip. Wide open windows, possible because hard coal is used." . . . Times change. . . . Continuing, he pointed out that the ultimate consumer is the master of markets today, that he is impressed by what engineers tell him and should, therefore, be given engineering facts, research and laboratory data.

■ **New Dean**—W. R. Woolrich, who has contributed several articles to these pages, has been appointed dean of the College of Engineering of the University of Texas at Austin. He was formerly professor of mechanical engineering at the University of Tennessee . . . Homer Addams, president of Fitzgibbons Boiler Co., was elected president of the *Steel Heating Boiler Institute* at the annual meeting last month; C. N. Tull, president of Spencer Heater Co., and J. F. Johnston, president of Johnston Brothers, Inc., were named vice-presidents, and R. A. Locke, secretary-treasurer. Directors include Mr. Addams, Mr. Tull, J. R. Collette, vice-president of Pacific Steel Boiler Division, C. L. Crouse, vice-president of National Radiator Corp., R. B. Dickson, president of Kewanee Boiler Corp., J. T. Dillon, Jr., president of Titusville Iron Works, F. B. Metcalf, president of International Boiler Works, H. H. Peek, president of Lookout Boiler & Mfg. Co., and J. C. Trefts, president of Farrar & Trefts.

■ **Engineering Education** — Charles F. Scott, professor emeritus of electrical engineering at Yale University, was re-elected chairman of the *Engineers' Council for Professional Development* at the annual meeting in New York last month. Committee reports on engineering schools, student selection and guidance, and on professional training were approved, and the report on professional recognition was received and held over for discussion at a later meeting . . . Formal action in accrediting engineering curricula of educational institutions in New England and middle Atlantic states by the *E. C. P. D.* was announced last month by H. H. Henline, secretary of the council . . . Curricula in schools in other regions will be investigated during the coming year by the *E. C. P. D.'s* committee on engineering schools . . . A meeting to be held at Columbia University, New York City, Dec. 5, will focus attention on the humanities content of engineering curricula. Meeting is under the auspices of the *Society for the Promotion of Engineering Education.*

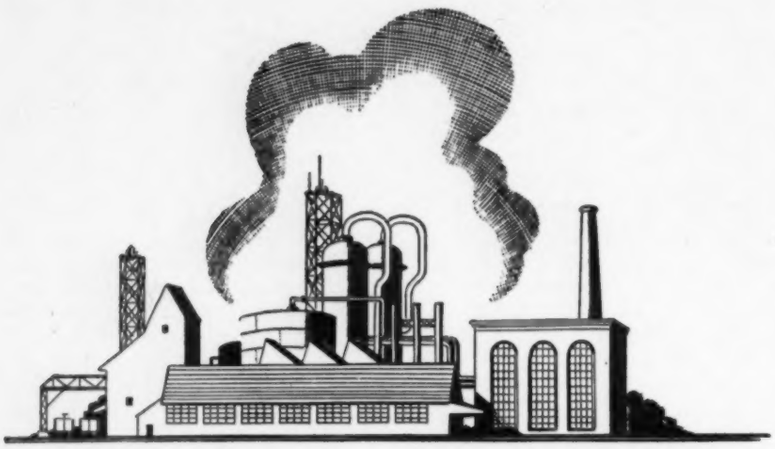
■ **Bust**—A bronze bust of Lord Kelvin, nineteenth century British physicist and pioneer in refrigeration and air conditioning, was presented to the Smithsonian Institution at a luncheon in Washington on Oct. 8. The gift was made possible by George W. Mason, president of Kelvinator Corp. . . . In a booklet "Lord Kelvin: Master of Heat and Cold," issued by The Temperature Research Foundation of Kelvinator Corp., Lord Kelvin is credited with realizing that temperature alone was not the key to proper living conditions, and long disapproved of the crude heating of homes. As early as 1852 he spoke on the economy of heating or cooling buildings by means of currents of air, and in 1874 he built a mansion on the Scottish coast with built-in heating and ventilating ducts . . . Plans for the merger of the Nash Motor Car Co. and Kelvinator Corp. have been adopted by the boards of directors of both companies, it was announced last month. The proposal provides for the new company being known as The Nash-Kelvinator Corp., with Charles W. Nash its chairman, Mr. Mason its president. . . . Prof. Elihu Thomson, pioneer in electrical science and holder of more than 800 patents, was honored last month when the Detroit section of the *American Welding Society* dedicated its program to the fiftieth anniversary of one of his most important inventions, that of resistance welding. . . . Prof. Thomson is one of the co-founders of the General Electric Co.; his numerous medals and awards include the Faraday, Kelvin and Hughes medals.

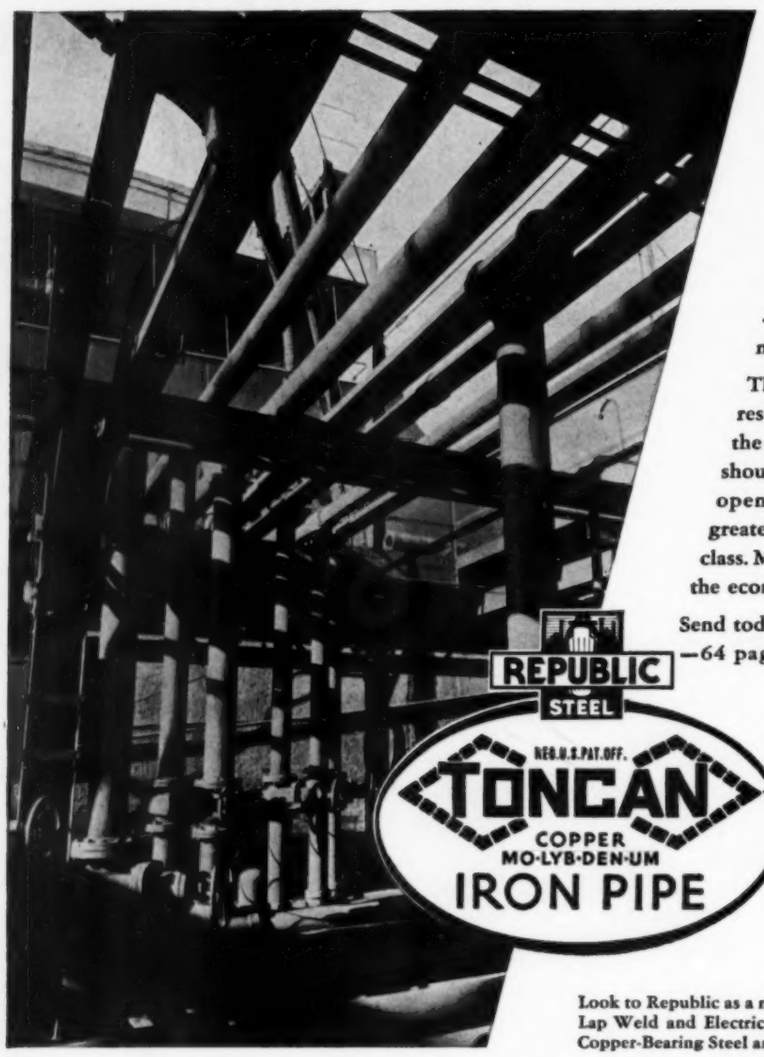
■ **Extra Pages**—When they are available—and they usually are—the editors are glad to supply tear sheets of pages of HEATING, PIPING AND AIR CONDITIONING to subscribers who want them to facilitate filing articles. Just drop a line to the editorial department, listing the issue and the numbers of the pages desired.

■ **Laboratory**—One of the most complete testing and research institutions in the heating industry has been established by Hoffman Specialty Co. in their recently completed laboratory at Stamford, Conn., according to Potter Bowles, president. . . . Ordinary methods of laboratory testing have been discarded in favor of equipment that duplicates exactly actual service conditions, according to the announcement. . . . Air conditioning will add to the comfort of the passengers who land at the Pan-Air do Brazil terminal at Rio de Janiero, according to the Carrier Corp., whose equipment conditions the second and third floors of the new building. Called the finest aerodrome in the world, the terminal is a combined marine and land transport air base along Rio's famous water front. . . . Chicago's first completely air conditioned apartment building is now under construction. Two tiers of six duplex apartments each will be provided and individual cooling units will service each apartment. . . . The board of directors of Byllesby Engineering and Management Corp. has announced

(*Continued on page* 127, *back section*)

It doesn't pay to skimp at the vital point - *THE PIPE*





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Published monthly by the Keeney Publishing Company, 6 N. Michigan Ave., Chicago. Telephone: State 6916/ F. P. Keeney, President; W. J. Osborn, Vice-President; R. Payne Wettstein, Secretary; Chas. E. Price, Treasurer/ Address all correspondence to Chicago office/ New York office, Room 1950, Grand Central Terminal Bldg. Telephone: Murray Hill 2-8293/ Cleveland office, 2047 Rossmoor Road. Telephone: Yellowstone 1540/ Los Angeles office, 1406 S. Grand Ave. Telephone: Richmond 6191/ Subscriptions: U. S. and possessions, Canada, Mexico, Central America, South America, $2.00 per year; other, $4.00. Current copies, U. S. and possessions, 25c each, back copies 50c each. January, 1936, issue, $1.00 per copy/ Member of Audit Bureau of Circulations/ Member of The Associated Business Papers, Inc./

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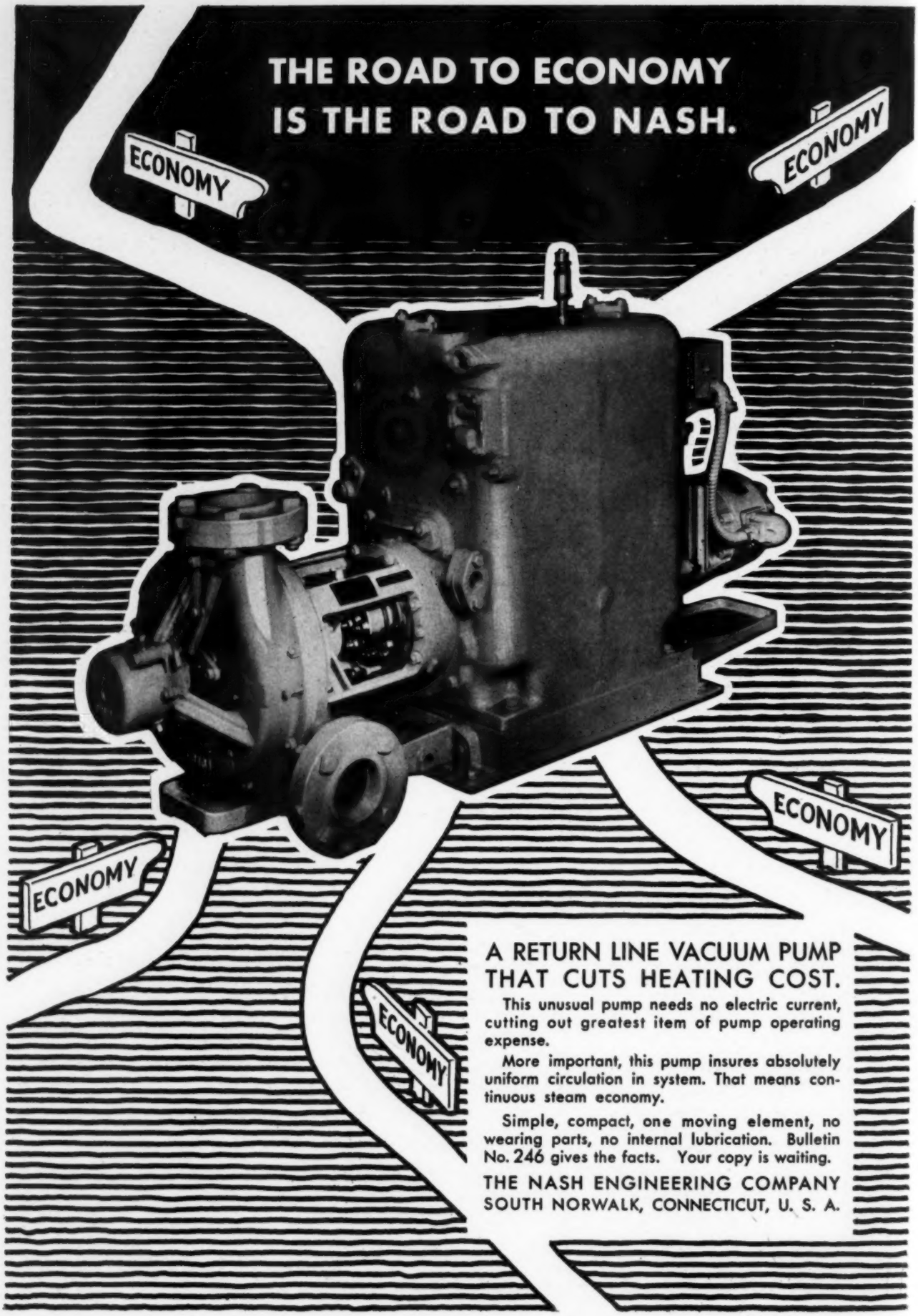

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Heating · Piping and Air Conditioning
Vol. 8, No. 11 • November, 1936

Unit Heating and Cooling

By Samuel R. Lewis*

Notes on the application, installation and control of unit heating and cooling machines in industrial and other buildings

ONE of the interesting mechanical developments of the age is the adoption of production methods in manufacturing. One result of such methods of course is the turning out of an enormous volume of the product at low cost.

Called upon to design the heating of an industrial plant, the engineer is quite likely to employ unit type heaters, which are usually assembled on a production line and delivered ready to operate as soon as power, controls, and piping are connected. In many cases units are more efficient than a central heat and air distributing system because heat can be transported with less loss by small insulated pipes than by large ducts, and because of the economy with which electrical energy may be distributed.

For instance, less power is required to deliver 15,000 cfm of air to 10 different rooms or zones with 10 unit heaters at, say, 1500 cfm each, than is required to deliver 15,000 cfm to the same rooms or zones through ducts. The 10 units may consume something like 2.5 hp while the single unit may require as much as 4 hp. When the filtering and warming and the controlling of temperature of air introduced for ventilating purposes from out-of-doors is considered, of course the complication and cost involved in providing and controlling a number of separate units with their various intake openings, air filters, tempering heaters and the piping, valves and electric wiring, may offset the saving that otherwise might be made. Thus, a study of the individual case is required in order that the proper system may be chosen.

Unit Heating and Ventilating

For this reason, although unit heaters practically have supplanted direct radiators for most industrial applications, they have not found as universal adoption for individual room application in other buildings. There are, however, many types of unit ventilating and heating machines available. Some of the apparatus necessary for each such unit is suggested in Fig. 1.

Only the room thermostat, Fig. 1, may serve more than one unit; the other controls all must be provided for each machine. The adjustment is arranged so that if no energy passes to the unit the steam supply valve will be open and the air inlet damper will be closed due to spring action. When the fan motor starts, the air supply damper opens. If the room temperature is colder than that desired by the room thermostat the steam valve will be open; if the room temperature is warmer than that desired by the room thermostat, the steam valve will close, which will result in cool air entering the room. The air stream thermostat stands guard against draft complaints by causing a gradual adjustment of the steam supply valve regardless of the room thermostat, so as to maintain an air delivery temperature never cooler than, say, 60 F. All of this control may be pneumatic as well as electric, using pressure-actuated electric switches for the motor controls.

Fan equipped ventilating machines taking air from out-of-doors condense the steam so rapidly in cold weather that mechanically induced circulation of the heating medium, as by a vacuum pump or a water circu-

*Consulting Engineer, Chicago, Ill., Member of Board of Consulting and Contributing Editors.

lating pump, must be employed to insure that there shall be no freezing.

Recirculating Unit Heaters

With thermally circulating steam or hot water heating, it has been customary, when basement rooms must have heat, to install ceiling type radiators so that they may be placed above the mains. Such radiators are inefficient because of stratification of the warm air overhead, and are unsightly. The radiant heat from them is never pleasant as it beats down from above. Small electric driven unit heaters solve this difficulty admirably, since they can be placed above the steam or water mains, yet will deliver the warm air downward and alleviate the stratification. A typical control arrangement for such a heater is shown in Fig. 2.

The fan motor may be controlled at full voltage through the relay or if the motor is of small size the line voltage may be used throughout. The room thermostat may control or the snap switch may bring about operation of the fan as for summer cooling. In winter, should the thermostat demand heat, the motor valve on the steam supply will be opened, but the fan will not operate (lest it cause cold drafts) until the return pipe, to which the aquastat switch responds, permits energy to pass to the fan motor.

In foundries, machine shops and heavy manufacturing plants where crane-ways must be kept clear of ducts and other obstructions, recirculating unit heaters are a useful recourse, since they can be placed above the cranes and can force the air downward so as to warm the working spaces. Or, they may be placed under the crane tracks with horizontal diffusion, where they will not interfere with the free travel of the material in course of manufacture.

At the left of Fig. 3 the units are above the cranes and deliver the air toward the floor at high velocity. Locating the supply and return piping for such an installation may be difficult because of the crane clearances. At the right the unit heaters are under the craneways. The supply and return piping may be placed directly under the crane girders but if the heating medium is steam, the return piping may have to be (most objectionably) placed under the floor. Forced hot water heating, with which the units may be below the mains, is useful in this case.

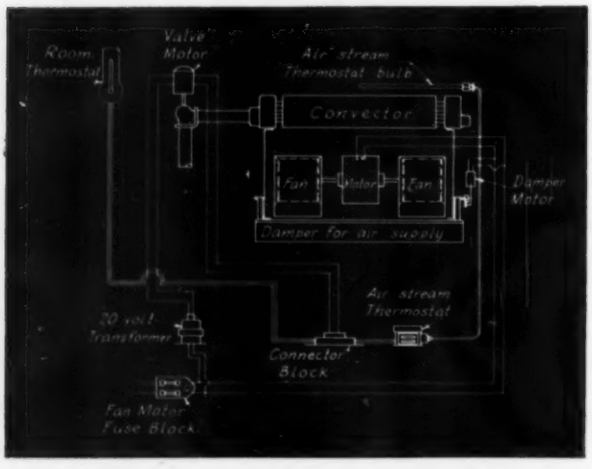


Fig. 1—Controls for a typical unit ventilator

Cooling with Units

Units are invaluable to the engineer when he is presented with a cooling problem, since with the comparatively slight difference which exists between the temperature of the cooling medium and that of the air, it is necessary to employ mechanically induced air circulation. Thus separate rooms in a building may have an unobtrusive individual cooling unit which will permit of local temperature control in proportion to occupancy and to solar heat gain. When pumped water is the heat transferring medium, the same individual convector and the same pipes and controls may be employed the year around, extracting heat from the air in summer and adding it in winter.

The central ventilating unit, Fig. 4, may deliver dehumidified air at a temperature desirable for the room which has the least heat gain, say Room 1 (Fig. 4), controlled by the duct thermostat. If the temperature in any of the rooms rises, as it will due to the variable solar heat gain or increased occupancy, the thermostat in that room will cause operation of the fans in the local cooling units. If the temperature in any of the rooms becomes too low, the room thermostat causes the fan in the local cooling unit to cease operation until the room becomes warm.

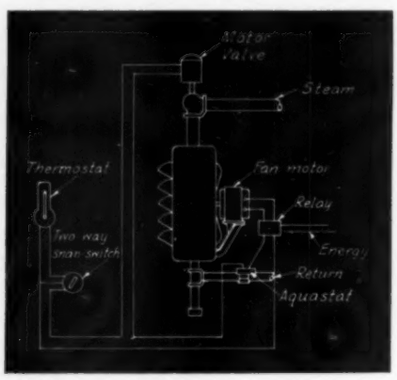


Fig. 2—Control arrangement for a recirculating type unit heater

For winter with the same apparatus, the thermostats reverse their influence so as to cause operation of the fans whenever the rooms become too cool. This reversing is a simple procedure with either pneumatic or electric temperature control and may be accomplished automatically by an outside thermostat.

Each unit will have a drain for carrying off the dew condensed out of the air in summer and the central unit will have a controlled water supply for adding moisture to the air in winter.

If water from a deep well is available for cooling, and if this water is not cold enough to accomplish dehumidification by chilling the air below its dew point, some of the convector units in any large space, such for instance as a store, may remove sensible heat while others may receive a cold refrigerant and may be devoted especially to dehumidification.

In one large cooling system for an office building

having about 30 rooms of varying size, the well water was not quite cold enough to accomplish moisture removal but was capable of cooling the outside air from about 95 F to 65 F. In this case a combination of central and unit systems was installed, with large unit convectors for each orientation for each story, yet with comparatively short air distributing duct systems for each. The air delivery temperature thus varies to some extent with the solar heat gain for each side of the building at different hours of the day. The air, cooled by water to 65 F, encounters direct expansion refrigerant convectors at about 40 F and thus is brought below its dew point

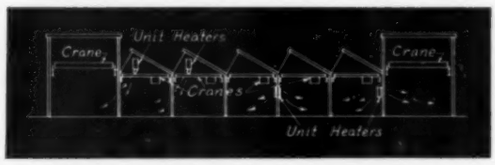


Fig. 3—Cross-section of factory illustrating two methods of unit heater application

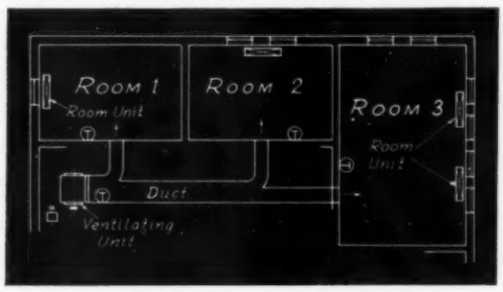


Fig. 4—Arrangement with four room units and a central ventilating unit. All units receive cold water in summer and hot water in winter

temperature and is controlled so that the delivery temperature is at about 60 F, permitting the maintenance of a room condition of 78 F dry bulb and a relative humidity of around 50 per cent.

In another plant, the air supply units, mounted overhead, include both supply and exhaust fans, the latter being driven by the same motors that drive the supply fans, so that the air removal is proportioned automatically at the unit in relation to the air supply volume. The exhaust fans may discharge back to the supply system or may discharge out-of-doors; with three interlocked dampers permitting more or less outside air with proportionate exhaust and always insuring commensurate recirculation as the outside air and exhaust dampers are throttled. This arrangement prevents the condition frequently encountered in cooling systems designed for recirculation only and not having adequate out-board exhaust—the inability to take full advantage of the cool outside air during the days and nights when otherwise the refrigerating plant would be operating.

Location of Unit Heaters

There are no fixed rules for height above the floor for locating overhead unit heaters, this being a function of the permissible air delivery velocity and this again being reflected by the permissible noise level and by the type of fan employed. Where propeller type fans are used, the units ordinarily give best results if not more than 10 ft above the floor, and if located rather near the outer

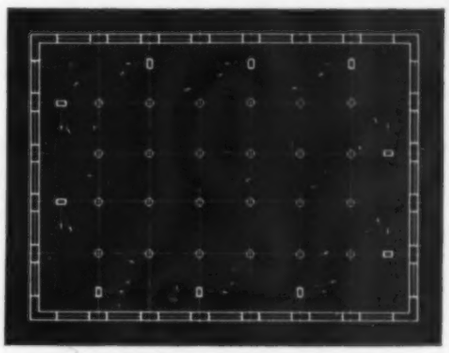


Fig. 5—Typical location of small overhead type unit heaters for one large room

walls or windows. The machines preferably should pass the air along, each to the other, rather than to oppose each other. In factory service one of these small units every 40 ft around the edges of the room may give excellent results (Fig. 5). The arrangement is such that each heater relays the air toward its neighbor so as gradually to bring about a rotary movement of the room air.

Where centrifugal fans, with their higher outlet velocity and more easily controllable diffusion are employed, the distance between units often is increased to 80 or even to 100 ft, depending of course on the refinement of air diffusion which must be maintained. With these units it is not usual to follow the relayed air circulation shown in Fig. 5.

Plant Maintenance Engineer Asks Unit Heater Information

A plant maintenance engineer and H. P. & A. C. reader asks the following questions, which are printed with Mr. Lewis' answers:

How high above the floor can units be safely placed?

There are many successful installations with the units placed as much as 40 ft above the floor. The upper limit has never been reached.

What speed of air flow is best, and why?

Speed of air flow is governed by type of occupancy, height of unit above floor, quality of building construction, etc. The air must not strike people at so high a speed as to create discomfort, but some people with their feet on the floor of a room may not be uncomfortable due to air blast from a unit heater 20 ft overhead which has a properly diffused outlet velocity of 2000 fpm. Other people in the same room, however, may be uncomfortable and may have cold feet when a unit heater is only 6 ft above the floor with an outlet velocity of 300 fpm. Factories, garages, gymnasiums and the like may very satisfactorily be served by unit heaters, but if these same *rooms* were used as offices or living rooms, the same arrangement might not be satisfactory. Therefore the question cannot be answered definitely.

What steam pressure is most economical taking into consideration first cost and future cost of operation?

There is a considerable experience and much literature to indicate that the most economical steam pressure for use in unit heaters is the lowest steam pressure that can be circulated; sub atmospheric during mild weather and never more than about 2 lb above atmospheric pressure. This permits of sub atmospheric vaporization in the boiler, with the greatest possible temperature difference between the water and the products of combustion.

With sub atmospheric steam circulation the piping usually is smaller than when higher pressure is used, reducing the investment. High pressure stream, say 50 lb or so, may be employed in unit heaters, and the piping may be very small under such circumstances, but there is often difficulty in removing the air from the piping and the convectors, and trouble with corrosion due to excess oxygen in the presence of moisture and high temperature.

Absorption Refrigeration Unit Cools Brine for Air Conditioning an Inn

By B. H. Jennings*

One of the few air conditioning installations employing an absorption refrigeration unit is described. Steam at 10 lb pressure is supplied the unit from a fully automatic boiler fired with anthracite coal. A further interesting feature is the use of a brine storage tank, which enables handling the 20 ton peak cooling load with a refrigeration unit rated at 12 tons

ONE of the few air conditioning systems using absorption refrigeration for all cooling requirements is installed at the Tressler Inn, Trevorton,—near Shamokin—Pa., in the anthracite coal region.

This Inn, Fig. 1, which serves as a restaurant and hotel, is a frame building 80 ft long by 50 ft deep. The first floor comprises the main dining room, which is also used for dancing, the kitchen, a smaller dining and bar room, toilets and an office. The second floor comprises ten bedrooms, a private dining room, a kitchen or serving room and a recreation room. Both of these floors, representing a total volume of 72,000 cu ft, are air conditioned throughout.

An attic above the second floor has some unfinished rooms and houses one of the conditioners and the duct work feeding the second floor rooms with conditioned air. The basement houses the boiler unit, absorption refrigeration unit, a conditioner, and a brine storage tank. The basement also has a cold storage room and a large space originally intended for a garage which has been converted into a dance floor. Fig. 2 is an isometric view of the basement floor showing this equipment.

For summer operation it was estimated that the peak refrigeration tonnage under crowded conditions and high temperatures would be in excess of 20 tons for periods not usually exceeding six hours. However, it was found that by using a brine storage system a rated 12 ton unit could handle the requirements by running more or less continuously to keep the brine at a low temperature. Under heavy loads the total charge of brine, roughly 10,000 gallons, rises in temperature several degrees even with the machine running. At night and when the large human load is not present, the unit soon brings the brine back to its normal cut off temperature. The brine is stored in a cork insulated concrete tank.

It was necessary also to supply refrigeration for food storage and liquid cooling purposes, brine temperatures between 20 and 30 F being required for this service. The whole brine system therefore is operated with the unit shutting off at 20 F. With a well-built absorption machine, a moderately decreased evaporator temperature entails but little additional steam and water consumption over that for the higher evaporator temperature which could be carried for air conditioning only. For this reason it is possible and reasonably economical to operate such a unit at the lower evaporator temperatures.

Steam for heating in winter, and at 10 lb pressure for operating the absorption refrigeration machine in warm weather, is supplied by a completely automatic boiler unit fired with anthracite coal. Coal flows by gravity from an overhead bunker to the furnace, and ashes are automatically removed by a conveyor system. No manual control or attention is required.

The absorption refrigeration unit, Figs. 2 and 3, is compactly built. The vessels in the picture, from the bottom up, are the absorber; the insulated generator, surrounded by a double pipe, coil type, heat exchanger; the condenser (on top).[1] In back of these elements are a small rectifier and the cork covered brine cooler or evaporator. On the floor beneath the unit is the small motor driven pump for circulating the refrigerant-solvent mixture. This motor and some of the electrically operated controls on the unit are the only devices in the refrigeration unit itself requiring power.

Circulating water at about 58 F is supplied from a well (of ample capacity so that recirculation is not required) and passes through the refrigerator elements in series—absorber, condenser and rectifier. Without de-

[*Concluded on page 604*]

Fig. 1—The Tressler Inn, in the Pennsylvania anthracite region, cooled by an absorption refrigeration air conditioning system

*Associate Professor of Mechanical Engineering, Lehigh University, Bethlehem, Pa., and Consulting Engineer for Philadelphia & Reading Coal & Iron Co.

[1]Principle of operation of the ammonia absorption system is based on the fact that ammonia from the evaporator can be absorbed in large quantity by cool aqua (ammonia-water solution). A small pump delivers saturated aqua from the absorber chamber into the generator where the steam heating releases the previously absorbed ammonia and this vapor in turn passes into the condenser. The boiled out solution then returns to the absorber to take up a fresh charge of ammonia. The rest of the system is exactly like a compression system. Heat from the steam is the energy supply for the system with a relatively negligible supply of power being required for the pump.

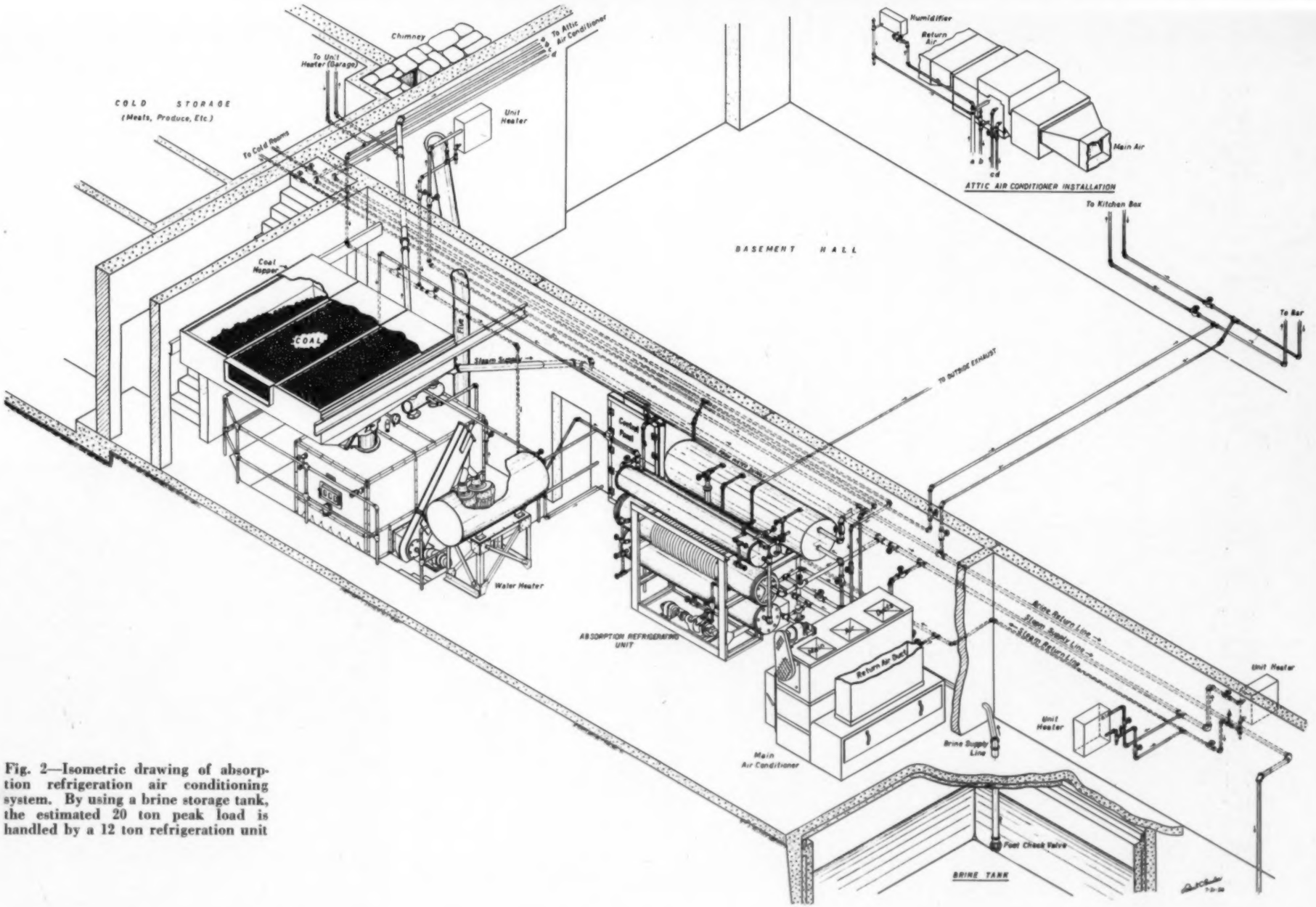


Fig. 2—Isometric drawing of absorption refrigeration air conditioning system. By using a brine storage tank, the estimated 20 ton peak load is handled by a 12 ton refrigeration unit

Correcting Flow Meter Readings

By **William Goodman***

IT is a human tendency to trust implicitly in instrument readings. And no wonder—many of them are extraordinarily ingenious in their construction and in their utilization of physical laws.

Modern flow meters rank high in accuracy and dependability. However, no flow meter will provide accurate records if it is improperly applied. A case in point is a large theater and apartment building to which the writer was called some time ago. Under the terms of the lease, the theater paid for all steam which it used.

The complaint of the theater operator was not an unusual one—high heating costs. But in this case it was complicated by the fact that the past winter had been mild compared to the preceding two winters, yet steam costs for the mild winter were as high as for either of the preceding two years. Added to this, the theater operator had made every effort to reduce the quantity of steam needed; to this end some return air had been recirculated, where in preceding years it had been the custom to use 100 per cent outside air.

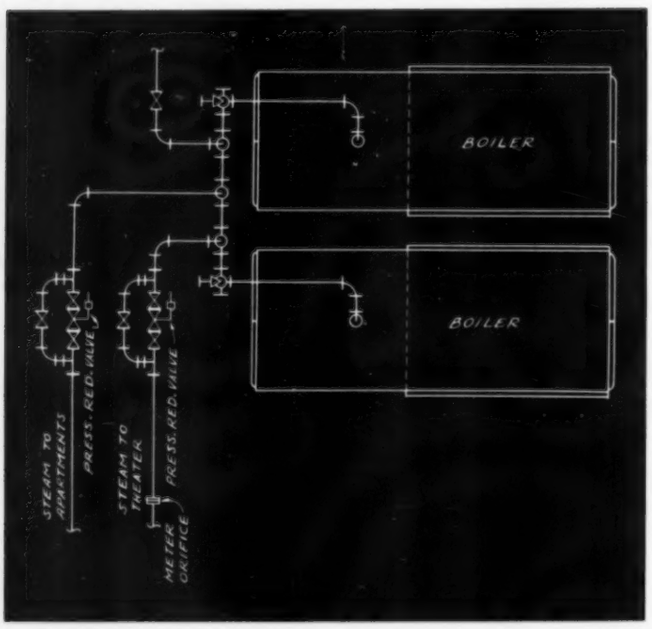
Steam supplied to the theater was measured by an electric flow meter consisting of an orifice in the steam line and its associated electrical and recording apparatus. The heating system was a typical two pipe vacuum job with the boilers situated in the apartment section of the building. Two separate steam mains, Fig. 1, delivered steam to the apartment and theater heating systems, respectively. Two hand fired boilers provided the necessary steam.

Duplicate vacum pumps maintained the needed vacuum in the return piping and pumped the condensate into the boilers. Thermostatic traps were provided on the returns from all radiators, and float traps on the blast coils in the ventilating system. Pressure reducing valves had been installed originally on the two mains in order to permit steam at different pressures to be supplied to the theater and apartment building. At the same time, the pressure in these mains could be held steady regardless of the boiler pressure—as long as the latter pressure was higher than was needed in the mains.

In attempting to find the reason for the apparently high steam consumption, the first thought was steam leaking from the system. The entire theater piping system was examined. Since this inspection took place in the morning, no steam had been turned into the theater piping. Opening the steam valve to the theater lines, and throwing additional coal into the boilers, the operator soon had 2 lb pressure in the theater piping system, which was examined and found to be tight. The traps seemed to be functioning satisfactorily since the return lines did not feel excessively warm. Finding nothing, it was decided to observe actual operating conditions in the evening.

The first move that evening was to inspect the fan room. A mixture of 34 F outdoor air and 72 F return air was being drawn through the blast coils, approximately equal amounts of each being used so that the average entering air temperature was 53 F. A gauge in the fan room showed that steam was being supplied under a vacuum of 10 in. In answer to a comment on the high vacuums being carried, the engineer explained that this was the first heating season he had been doing so. As a consequence quite a saving in coal was being effected. In previous years, because of the theater blast heaters,

*The Trane Co., LaCrosse, Wis.



Steam flow meters are calibrated for service under certain conditions. If steam pressures are changed because of plant alterations or different operating methods, allowances must be made or meter readings will not represent the facts. The causes of incorrect readings are explained here, and methods of correction are given . . . . . This article was suggested by a "trouble shooting" experience of the author's, where meter readings were found to be too high because of changed operating methods

Fig. 1—Boiler room layout showing location of pressure reducing valves and flow meter orifice

it had been necessary to carry several pounds pressure on the boilers, whereas the boiler gauge now showed a vacuum of 8 in. As long as the air entering the blast heaters was below freezing temperature, it had been necessary to supply steam at about 5 lb pressure. Now that return air was being used, the necessity for steam at the higher pressure had disappeared.

The regulating valve on the theater supply main had originally been set to hold the pressure at 5 lb. This valve was installed on the theater steam main ahead of the flow meter, Fig. 1. The valve on the apartment building line had always been set to hold but a few ounces of pressure in this line. Steam was now being supplied to both the theater and apartment building through the bypasses around the reducing valves. Furthermore, the engineer had been operating the plant in this way since the beginning of the heating season.

The answer to the difficulty was now obvious. The flow meter had probably been calibrated for some higher pressure and now, operating under lower pressures, it was recording greater weights of steam than were actually flowing through it. It was found from the makers that the instrument was calibrated for a steam pressure of 5 lb gauge. The density of the steam under a vacuum of 8 in. is so much less than it is at 5 lb gauge, that the meter was recording a much greater weight of steam than was actually flowing through it.

Principle of Flow Meter Operation

No flow meter actually measures the weight of fluid passing through it. Fundamentally all that any meter measures and records is the elevation of a column of mercury in a manometer. The two sides of the manometer are connected separately into the steam pipe line before and after an orifice such as is shown in Fig. 2. Because of the resistance introduced by the orifice, a pressure drop takes place as the steam flows through it and this pressure drop is measured by the mercury manometer. Now, by means of a mathematical relationship and experimentally determined constants, it is possible to compute the weight of steam flowing through an orifice from the measured elevation of the mercury column. Commercial flow meters, instead of actually indicating and recording the elevation of the mercury column, are so calibrated that the weights of steam, corresponding to the different elevations of the mercury column, can be read directly.

In order to calibrate a meter in this way, the density and pressure of the steam which is to be measured must be known. For instance, the manometer in Fig. 2 has two scales which show the weights of steam flowing through the orifice for different heights of the mercury column. The left-hand scale would be used if the pressure of the steam in the main were 5 lb gauge, while the right-hand scale would be used if the steam were under a vacuum of 8 in. (10.8 lb absolute pressure). If the steam were at any pressure other than these two, either a new scale would be needed or it would be necessary to use a correction factor which could be applied to either scale. Recording meters, unlike the manometer illustrated in Fig. 2, are calibrated for only one steam pressure. If such a meter is used to record the weight of steam at any other pressure than the one for which it has been calibrated, its readings will be incorrect.

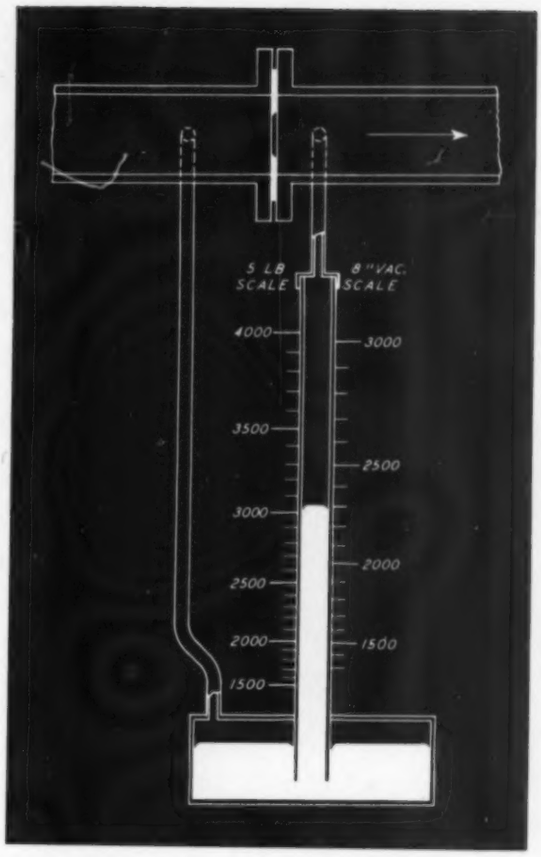


Fig. 2—Diagram of simple flow meter consisting of orifice and mercury manometer. The scales shown on both sides of the manometer are calibrated to read directly in lb per hr of steam flowing through the orifice. The left scale is calibrated for steam at 5 lb gauge while the right scale is calibrated for steam under a vacuum of 8 in. (10.8 lb absolute pressure)

Correcting for Pressure Changes

Mathematical analysis shows that for a given elevation of the mercury column, the actual weight of steam flowing through a meter orifice varies directly as the square root of its density. Hence, when the steam pressure is different from the pressure for which the meter was calibrated, the relation between the actual weight of steam flowing through the orifice and the weight recorded by the meter is given by

$$W = W_s \sqrt{\frac{d}{d_s}}$$

where

W = Actual weight of steam flowing through the orifice per hour.
W_s = Weight of steam recorded by the meter.
d = Density of the steam at its actual pressure.
d_s = Density of the steam under the standard pressure for which the meter was calibrated.

Hence for the conditions of this theater, if the engineer had been operating under an 8 in. vacuum most of the winter, the ratio between the actual weight of steam used and the amount recorded by the meter could be computed by means of the above formula. Thus, from Marks & Davis' steam tables,

Density of steam under 8 in. vacuum = 0.0280 lb per cu ft.
Density of steam under 5 lb gauge = 0.0489 lb per cu ft.

$$W = W_s \sqrt{\frac{0.0280}{0.0489}} = W_s \sqrt{0.573} = 0.757 \quad W_s$$

In other words, the actual weight of steam used was 75.7 per cent of the amount recorded by the meter. Had the pressure of the steam supplied to the theater been maintained at 5 lb gauge, the meter would have correctly recorded the reduced amount of steam. However, since the pressure was also reduced, the calibration of the meter caused it to record a greater weight than was actually used.

If steam had been supplied at a pressure higher than the one for which the meter was calibrated, the actual weight flowing through the orifice would have been greater than that recorded by the meter.

Where steam pressures vary, it is desirable to install an automatic compensating device which will automatically correct the meter record to compensate for variations in pressure from those for which the meter was calibrated.

Correcting for Steam Quality and Superheat

So far we have touched only upon the error due to lowering the pressure, which in turn means steam at a lower density. However, the density of steam does not vary only with pressure. It also varies both with changes in the dryness (quality) of the steam and with changes in its superheat. Thus, superheated steam has a lower density than saturated steam at the same pressure. If the meter is calibrated for saturated steam, while actually superheated steam flows through the orifice, it is apparent that the meter will record too great a weight of steam.

Pressure reducing valves are often used for the double purpose of providing low pressure steam and for holding a constant pressure at the meter. But saturated steam which is throttled from a high to a lower pressure by a reducing valve is always superheated during the process. In many hotels, for instance, steam is generated at 100 lb pressure and reduced to 2 lb pressure for heating. Under these conditions, if a meter calibrated for 2 lb *saturated* steam measures the weight of steam used for heating, it will record too great an amount. Either the steam must be de-superheated before it reaches the meter or the meter must be calibrated for superheated steam. For instance, if saturated steam at 100 lb gauge were throttled to 2 lb gauge, its superheat—as determined from a Mollier diagram—would be about 78 F above the saturation temperature corresponding to 2 lb gauge pressure.

Density of 2 lb (gauge press.) saturated steam ..... = 0.0420 lb per cu ft.
Density of 2 lb (gauge press.) steam superheated 78F ..... = 0.0380 lb per cu ft.

$$W = W_s \sqrt{\frac{0.038}{0.042}} = 0.951 \; W_s$$

In other words, the amount of steam actually used would be 95.1 per cent of the amount recorded by the meter. It is always necessary to be careful when placing meters immediately after pressure reducing valves.

Another source of error which is sometimes overlooked is the dryness of the steam; the dryer the steam the greater will be its density. Thus, a meter calibrated for dry (saturated) steam would read high if wet steam flowed through it. If an excessive amount of condensation took place in the steam line ahead of the orifice, the meter would record too great a weight of steam.

Plant Alterations Cause Meter Errors

It is possible to have comparatively large errors in the recorded weights of flowing steam, if meters are used under conditions which differ much from those for which the meter was calibrated. While an installation originally made under the supervision of the meter manufacturer will usually be satisfactory, plant alterations made later are apt to cause meter errors. While these alterations may in themselves be minor, they are likely to have a marked effect upon the accuracy of the meter. Any change that alters the density of the steam from that for which the meter was originally calibrated will require the use of either a correction factor or a meter compensating device.

A. C. Benefits Surgical Supply Company

The E. F. Mahady Surgical Supply Co., Boston, Mass., employs air conditioning in the handling of their suture product in order to produce an atmosphere as nearly sterile as mechanically possible. (A suture is an animal product employed in closing surgical incisions; its quality and sterility is most important.)

The system was designed in accordance with specifications issued by a chemical engineer who was retained as consultant, and who emphasized that it was imperative to introduce the conditioned air in such manner as to obviate drafts, at the same time enabling varying of the air volume. This was necessary for technical reasons connected with control of the product. The refrigerating and air handling equipment is situated in a separate room completely isolated from the suture room.

There are several steps from the raw material to the finished product. The raw suture material is first brought into a non-sterile room where it undergoes mechanical preparation such as unwinding, sorting, and finally is inserted into tubes. The racked tubes are then passed into the sterilizing room and placed into the sterilizer where they are held one hour at 160 C. From the sterilizing room they are passed into a small room where alcohol is added to the tubes. From here the racks are passed into the sealing room. This room contains a glass enclosure approximately 60 in. long by 18 in. wide by 24 in. high, which contains two sealing burners. Two girls seal the glass suture tubes, there being sufficient space allowed at the bottom of the glass enclosure for the girls to insert their arms and thus work freely. Upon the conclusion of this operation, the product is packed in containers and is ready for marketing.

Since the beginning of these operations under the influence of air conditioning, the company has not lost one tube of suture due to contamination; culture tests of room conditions have been taken and far exceeded expectations. In addition to increasing the overall profit picture on the product, the employees have not lost one day through sickness, whereas before air conditioning was installed, six or seven days per year were lost. Thus the owner has benefited in two ways by air conditioning.
—J. E. O'Neill.*

*York Ice Machinery Corp., Boston, Mass.

Use of American Standard Pipe Thickness Schedules

Part 2

By **Arthur McCutchan***

The schedules of pipe wall thicknesses of the American Standard for Wrought Iron and Wrought Steel Pipe—approved as a tentative standard last November—were described and their use explained in Part 1. An example showing the method of selection of the schedule of pipe thickness was given, and two tables of the dimensional properties of pipe used in computing steam and water velocities, pressure drops and flexural characteristics of pipe lines were presented. . . . Part 2 presents tables covering other pipe schedules and explains the significance of the properties tabulated and their use in piping design

IN tracing the origin and development of the American Standard Pipe Thickness Schedules in Part 1,[1] it was shown that adherence to these schedules will substantially diminish the number of wall thicknesses required by the piping industry, which in turn will tend to reduce the items carried in jobber's stock for small orders.

The first two tables of a series covering the dimensional properties of pipe conforming to these schedule numbers were presented with Part 1. Table 1 covered the properties of Schedule 40 pipe, which in sizes 10 in. and smaller corresponds to the old "standard weight" pipe. Table 2 covered Schedules 10, 20 and 30 pipe which is sometimes referred to as "thin-wall" pipe. Tables 3 to 6 cover the full range Schedules 80, 120 and 160, and intermediate Schedules 60, 100 and 140.

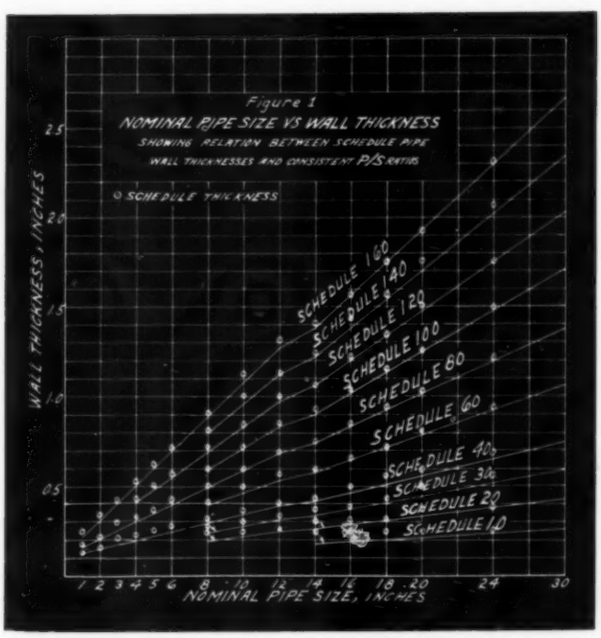
A better idea of the significance of the P/S ratios,[2] referred to in Part 1, and the reasons for some schedules extending through the small sizes while others do not is afforded in Fig. 1. In this figure the nominal pipe size vs the computed wall thickness for each P/S ratio chosen for a schedule number is represented by a separate line. The divergence of the lines as they radiate from the origin of the plot demonstrates the reason more schedules of wall thickness are needed in the large pipe sizes than in the small sizes where the radiant lines are relatively close together.

The fact that the wall thicknesses selected were in some cases thicker than the computed values is shown by the individual points spotted adjacent to the theoretical lines. Because the wall thicknesses are plotted against nominal pipe size in this figure rather than against outside diameter, there is a change in slope of the lines between the 12 and 14 in. sizes but this difference in slope does not mean that the ratios of P/S are inconsistent.

Incidentally, the correspondence between actual plotted thickness and consistent P/S lines shown in the figure indicates to what extent computation for one pipe size of the working stress for a given service condition can be extended to the other sizes. For example, if calculations show that Schedule 160 wall thickness is satisfactory for the 16 in. pipe size which lies on the theoretical line, it can be determined from inspection of this figure that Schedule 160 will be adequate for the balance of the pipe sizes which lie on or above this theoretical line. Likewise, it is evident from this figure that computation of the 10 in. size which lies above this line does not necessarily show that the other sizes will have adequate wall thickness for the given service condition.

While, of course, no great novelty can be claimed for these tables beyond switching to schedule numbers, an effort has been made to include all the essential properties required in piping design without making the tables unduly complicated. Thus, the inside diameter to the fifth power is included since it appears in the majority of the formulas for pressure loss involving volume or weight of flow, while the section modulus has been omitted since it seldom is called for outside of structural design. Where needed for computing the strength of pipe used for structural supports, the section modulus S can be obtained quite simply from the relation $S = 2\,I/D$ since values for the outside diameter D and the moment of inertia I are given in the tables.

An eight-bank calculating machine was used in computing the values given in the tables for all but the pipe thicknesses which correspond to "standard weight" and "extra strong" designations. The properties of pipe for these latter wall thicknesses were taken from existing tables. The intermediate figures used in determining the



*Engineer, Engineering Division, The Detroit Edison Co., Detroit, Mich.

[1] HEATING, PIPING AND AIR CONDITIONING, October, 1936, pp. 531-535.

[2] The schedule numbers indicate approximate values of $1000 \times P/S$, in which P is working pressure and S allowable stress.

Table 3—Properties of Schedule 80 Pipe

Conforming to *A.S.A.* Standard B36.10 for Wrought Iron and Wrought Steel Pipe

Nominal Pipe Size in.	Outside Diam in. D	Wall Thickness* in. t	Inside Diam in. d	Inside Diam Squared d^2	Inside Diam Fifth Power d^5	Area of Metal Sq.In.	Internal Cross-Sectional Area Sq. In.	Internal Cross-Sectional Area Sq. Ft.[1]	External Surface Per ft Sq. Ft.	Moment of Inertia $in.^4$	Weight of Pipe Per ft Lb	Weight of Water Per ft of Pipe Lb
1/8	0.405	0.095	0.215	0.0462	0.000459	0.093	0.0363	0.00025	0.106	0.001216	0.32	0.0157
1/4	0.540	0.119	0.302	0.0912	0.002513	0.157	0.0716	0.00050	0.141	0.003766	0.54	0.031
3/8	0.675	0.126	0.423	0.1789	0.01354	0.217	0.1405	0.00098	0.177	0.008619	0.74	0.0609
1/2	0.840	0.147	0.546	0.2981	0.04852	0.320	0.2341	0.00163	0.220	0.02008	1.09	0.1013
3/4	1.050	0.154	0.742	0.5506	0.2249	0.433	0.4324	0.00300	0.275	0.04479	1.48	0.1875
1	1.315	0.179	0.957	0.9158	0.8027	0.639	0.7193	0.00499	0.344	0.1056	2.17	0.3112
1 1/4	1.660	0.191	1.278	1.633	3.409	0.881	1.283	0.00891	0.435	0.2418	3.00	0.5553
1 1/2	1.900	0.200	1.500	2.250	7.594	1.068	1.767	0.01225	0.498	0.3912	3.64	0.7648
2	2.375	0.218	1.939	3.760	27.41	1.477	2.953	0.02050	0.622	0.8679	5.03	1.279
2 1/2	2.875	0.276	2.323	5.396	67.64	2.254	4.238	0.02942	0.753	1.924	7.67	1.834
3	3.5	0.300	2.900	8.410	205.1	3.016	6.605	0.04587	0.917	3.894	10.3	2.859
3 1/2	4.0	0.318	3.364	11.32	430.8	3.678	8.891	0.06170	1.047	6.280	12.5	3.847
4	4.5	0.337	3.826	14.64	819.8	4.407	11.50	0.07986	1.178	9.610	15.0	4.976
5	5.563	0.375	4.813	23.16	2,583	6.112	18.19	0.1263	1.456	20.67	20.8	7.875
6	6.625	0.432	5.761	33.19	6,346	8.405	26.07	0.1810	1.734	40.49	28.6	11.29
8	8.625	0.500	7.625	58.14	25,775	12.76	45.66	0.3171	2.257	105.7	43.4	19.79
10	10.75	0.593	9.564	91.47	80,020	18.92	71.84	0.4989	2.817	244.8	64.4	31.13
12	12.75	0.687	11.376	129.41	190,523	26.03	101.64	0.7058	3.338	475.1	88.6	44.04
14 OD	14.0	0.750	12.500	156.25	305,176	31.22	122.72	0.8522	3.665	687.3	107	53.18
16 OD	16.0	0.843	14.314	204.89	600,904	40.14	160.92	1.1175	4.189	1,156	137	69.73
18 OD	18.0	0.937	16.126	260.05	1,090,518	50.23	204.24	1.4183	4.712	1,833	171	88.50
20 OD	20.0	1.031	17.938	321.77	1,857,248	61.44	252.72	1.7550	5.236	2,772	209	109.51
24 OD	24.0	1.218	21.564	465.01	4,662,798	87.17	365.22	2.5362	6.283	5,672	297	158.26

[1] This column also represents the contents in cu ft per ft of length.

*Underscored wall thicknesses are identical with thicknesses for "extra-strong" pipe in former tables

Table 4—Properties of Schedules 60 and 100 Pipe

Conforming to *A.S.A.* Standard B36.10 for Wrought Iron and Wrought Steel Pipe

Nominal Pipe Size in.	Outside Diam in. D	Wall Thickness* in. t	Inside Diam in. d	Inside Diam Squared d^2	Inside Diam Fifth Power d^5	Area of Metal Sq.In.	Internal Cross-Sectional Area Sq. In.	Internal Cross-Sectional Area Sq. Ft.[1]	External Surface Per ft Sq. Ft.	Moment of Inertia $in.^4$	Weight of Pipe Per ft Lb	Weight of Water Per ft of Pipe Lb
					SCHEDULE 60							
8	8.625	0.406	7.813	61.04	29,113	10.48	47.94	0.3329	2.258	88.73	35.7	20.77
10	10.75	0.500	9.75	95.06	88,110	16.10	74.66	0.5185	2.814	212.0	54.8	32.35
12	12.75	0.562	11.626	135.16	212,399	21.52	106.16	0.7372	3.338	400.4	73.2	46.00
14 OD	14.0	0.593	12.814	164.20	345,480	24.98	128.96	0.8956	3.665	562.3	85.0	55.86
16 OD	16.0	0.656	14.688	215.74	683,618	31.62	169.44	1.1766	4.189	932.4	108	73.42
18 OD	18.0	0.718	16.564	274.37	1,246,884	38.98	215.49	1.4964	4.712	1,458	133	93.38
20 OD	20.0	0.812	18.376	337.68	2,095,342	48.95	265.21	1.8417	5.236	2,257	167	114.92
24 OD	24.0	0.937	22.126	489.56	5,302,913	67.89	384.50	2.6701	6.283	4,521	231	166.61
					SCHEDULE 100							
8	8.625	0.593	7.439	55.34	22,781	14.96	43.46	0.3018	2.258	121.3	50.9	18.83
10	10.75	0.718	9.314	86.75	69,357	22.63	68.13	0.4732	2.814	286.1	77.0	29.53
12	12.75	0.843	11.064	122.41	165,791	31.53	96.14	0.6677	3.338	561.6	108	41.66
14 OD	14.0	0.937	12.126	147.04	262,173	38.45	115.49	0.8020	3.665	824.4	131	50.04
16 OD	16.0	1.031	13.938	194.27	526,020	48.48	152.58	1.0596	4.189	1,364	165	66.12
18 OD	18.0	1.156	15.688	246.11	950,250	61.17	193.30	1.3423	4.712	2,180	208	83.76
20 OD	20.0	1.250	17.50	306.25	1,641,309	73.63	240.53	1.6703	5.236	3,250	251	104.23
24 OD	24.0	1.500	21.00	441.00	4,084,101	106.03	346.36	2.4053	6.283	6,740	361	150.09

[1] This column also represents the contents in cu ft per ft of length.

*Underscored wall thickness is identical with the thickness for "extra-strong" pipe in former tables

Table 5—Properties of Schedules 120 and 140 Pipe

Conforming to *A.S.A.* Standard B36.10 for Wrought Iron and Wrought Steel Pipe

Nominal Pipe Size in.	Outside Diam in. D	Wall Thickness in. t	Inside Diam in. d	Inside Diam Squared d^2	Inside Diam Fifth Power d^5	Area of Metal Sq.In.	Internal Cross-Sectional Area Sq. In.	Internal Cross-Sectional Area Sq. Ft.[1]	External Surface Per ft Sq. Ft.	Moment of Inertia $in.^4$	Weight of Pipe Per ft Lb	Weight of Water Per ft of Pipe Lb
					SCHEDULE 120							
4	4.5	0.437	3.626	13.15	626.8	5.578	10.33	0.0717	1.178	11.65	19.0	4.47
5	5.563	0.500	4.563	20.82	1,978	7.953	16.35	0.1136	1.456	25.73	27.1	7.09
6	6.625	0.562	5.501	30.26	5,037	10.705	23.77	0.1650	1.734	49.61	36.4	10.30
8	8.625	0.718	7.189	51.68	19,202	17.84	40.59	0.2819	2.257	140.5	60.7	17.59
10	10.75	0.843	9.064	82.16	61,179	26.24	64.53	0.4481	2.817	324.2	89.2	27.96
12	12.75	1.000	10.750	115.56	143,563	36.91	90.76	0.6303	3.338	641.6	126	39.33
14 OD	14.0	1.062	11.876	141.04	236,239	43.17	110.77	0.7693	3.665	909.3	147	48.00
16 OD	16.0	1.218	13.564	183.98	459,133	56.56	144.50	1.0035	4.189	1,555	193	62.62
18 OD	18.0	1.343	15.314	234.52	842,254	70.28	184.19	1.2791	4.712	2,453	239	79.81
20 OD	20.0	1.500	17.000	289.00	1,419,857	87.18	226.98	1.5762	5.236	3,754	297	98.35
24 OD	24.0	1.750	20.500	420.25	3,620,506	122.33	330.06	2.2921	6.283	7,617	416	143.03
					SCHEDULE 140							
8	8.625	0.812	7.001	49.01	16,819	19.93	38.50	0.2673	2.257	153.7	67.8	16.68
10	10.75	1.000	8.750	76.56	51,291	30.63	60.13	0.4176	2.817	367.8	105	26.06
12	12.75	1.125	10.500	110.25	127,628	41.08	86.59	0.6013	3.338	700.5	140	37.52
14 OD	14.0	1.250	11.500	132.25	201,136	50.07	103.87	0.7213	3.665	1,027	171	45.01
16 OD	16.0	1.437	13.126	172.29	389,670	65.74	135.32	0.9397	4.189	1,760	224	58.64
18 OD	18.0	1.562	14.876	221.30	728,502	80.66	173.80	1.2070	4.712	2,749	275	75.32
20 OD	20.0	1.750	16.500	272.25	1,222,981	100.33	213.82	1.4849	5.236	4,216	342	92.66
24 OD	24.0	2.062	19.876	395.06	3,102,022	142.11	310.28	2.1547	6.283	8,625	484	134.45

[1] This column also represents the contents in cu ft per ft of length.

Table 6—Properties of Schedule 160 Pipe

Conforming to *A.S.A.* Standard B36.10 for Wrought Iron and Wrought Steel Pipe

Nominal Pipe Size in.	Outside Diam in. D	Wall Thickness in. t	Inside Diam in. d	Inside Diam Squared d^2	Inside Diam Fifth Power d^5	Area of Metal Sq.In.	Internal Cross-Sectional Area Sq. In.	Internal Cross-Sectional Area Sq. Ft.[1]	External Surface Per ft Sq. Ft.	Moment of Inertia $in.^4$	Weight of Pipe Per ft Lb	Weight of Water Per ft of Pipe Lb
1/2	0.840	0.187	0.466	0.2172	0.002197	0.3836	0.1706	0.00118	0.220	0.02212	1.31	0.074
3/4	1.050	0.218	0.614	0.3770	0.08726	0.5698	0.2961	0.00206	0.275	0.05269	1.94	0.130
1	1.315	0.250	0.815	0.6642	0.3596	0.8365	0.5217	0.00362	0.344	0.1251	2.85	0.230
1 1/4	1.660	0.250	1.160	1.346	2.100	1.107	1.057	0.00734	0.435	0.2839	3.77	0.46
1 1/2	1.900	0.281	1.338	1.790	4.288	1.429	1.406	0.00976	0.498	0.4824	4.86	0.61
2	2.375	0.343	1.689	2.853	13.74	2.190	2.241	0.01556	0.622	1.162	7.45	0.97
2 1/2	2.875	0.375	2.125	4.516	43.33	2.945	3.546	0.02463	0.753	2.353	10.0	1.54
3	3.5	0.437	2.626	6.896	124.9	4.205	5.416	0.03761	0.917	5.032	14.3	2.35
3 1/2	4.0											
4	4.5	0.531	3.438	11.82	480.3	6.621	9.283	0.06447	1.178	13.27	22.6	4.02
5	5.563	0.625	4.313	18.60	1,492	9.696	14.61	0.1015	1.456	30.03	33.0	6.33
6	6.625	0.718	5.189	26.93	3,762	13.32	21.15	0.1469	1.734	58.97	45.3	9.16
8	8.625	0.906	6.813	46.42	14,679	21.97	36.46	0.2532	2.257	165.9	74.7	15.80
10	10.75	1.125	8.500	72.25	44,371	34.02	56.75	0.3941	2.817	399.3	116	24.59
12	12.75	1.312	10.126	102.54	106,461	47.14	80.53	0.5592	3.338	781.1	161	34.89
14 OD	14.0	1.406	11.188	125.17	175,292	55.63	98.31	0.6827	3.665	1,117	190	42.60
16 OD	16.0	1.562	12.876	165.79	353,920	70.85	130.21	0.9043	4.189	1,868	241	46.43
18 OD	18.0	1.750	14.500	210.25	640,973	89.34	165.13	1.1467	4.712	2,983	304	71.55
20 OD	20.0	1.937	16.126	260.05	1,090,519	109.9	204.24	1.4183	5.236	4,534	374	88.50
24 OD	24.0	2.312	19.376	375.43	2,730,993	157.5	294.86	2.0476	6.283	9,367	536	127.77

[1] This column also represents the contents in cu ft per ft of length.

moment of inertia, inside diameter to the fifth power, and the like, were carried out to eight places to insure numerical accuracy, although commercial variations in wall thickness render extreme accuracy meaningless.

Significance of Properties Tabulated

In addition to their convenience these tables permit a more reliable calculation of the velocity, pressure loss, and flexural properties of a given pipe line than ordinarily would be obtained if the individual properties were computed for a single isolated instance directly from the pipe dimensions without the check afforded by the computation of properties for contiguous thicknesses. The significance and usefulness of the various properties listed in the tables are summarized below.

Inside Diameter—The inside diameter, sometimes referred to as the "actual inside diameter," is used directly in solving pressure loss problems by the aid of such charts as that based on Fritzsche's formula[3] for the flow of superheated steam. It also is used in determining the friction factor f in the "rational" or general flow formulas which are based on functions of the Reynolds number. Care must be exercised in determining this friction factor to insure that the inside diameter is properly expressed in feet or inches as the particular formula requires. This precaution was pointed out in a recent article by Benjamin.[4] Under turbulent flow conditions it is useful to note that the pressure drop for a given velocity of flow varies inversely as the inside diameter.

Inside Diameter Squared—The inside diameter squared appears in Clavarino's formula for stress in thick walled pipes. In formulas for viscous flow the pressure drop for a given velocity varies inversely as the square of the inside diameter of the pipe.

Inside Diameter to Fifth Power—The inside diameter to the fifth power appears in the "rational" or general flow formulas where volume or weight of flow is used and in the majority of the empirical formulas for flow of steam, water, oil and gas. Fritzsche's formula for superheated steam flow employs the inside diameter to the 4.97 power, while Weymouth's formula for flow of gas contains the inside diameter to the 5.33 power. With these minor exceptions, the pressure loss in pipe where flow is expressed in volume or weight of fluid can be considered to vary inversely as the inside diameter to the fifth power.

Area of Metal—The cross-sectional area of metal enters into the calculation of the effects of end thrust imposed by constraint of thermal elongation of the line.

Internal Cross-Sectional Area—The internal cross-sectional area in square inches and square feet facilitates calculations of velocities of flow. The area in square feet gives directly the contents in cubic feet per foot of length.

External Surface—The square feet of external surface per foot of length is useful in calculating the total heat loss from the bare pipe surface when the loss per square foot is known or assumed for a given operating condition.

Moment of Inertia—The moment of inertia appears in all computations of bending stress in pipe. It is used in determining reacting forces set up by constraint of thermal elongation, and in estimating the rigidity of all piping structures.

Weight of Pipe per Foot—These pipe weights are taken from *A.S.A.* B36-10. Pipe weights are used in checking the cost of pipe, in computing shipping costs, and in providing means for handling the pipe from the railroad car to position. The latter is important when it is appreciated that a 30 ft length of 16 in. Schedule 80 pipe weighs over two tons. The provision of hangers and supports for such heavy pipe is in itself no small job.

Weight of Water per Foot of Pipe—In computing the dimensions of hangers and supports, it is customary to assume the pipe to be full of water, even if the lines are intended for superheated steam. In spacing the supports and pitching steam lines, the deflection of the line between supports must be taken into account. The weight of water in the larger pipe sizes exceeds the weight of pipe. The weight of water, therefore, is an important factor in determining the deflection between supports.

While, as pointed out at the beginning of this article, it was not the intent in establishing the standard pipe thickness schedules to rule out other thicknesses for which mill equipment is available and the quantity of pipe warrants a special rolling, the advantage of adhering to the schedule thicknesses is quite evident when all the problems of piping design are considered. The full value of this standardization of pipe thicknesses will be realized only when consumers, pipe fabricators and pipe manufacturers follow the scheduled thicknesses consistently in preference to non-standard or special thicknesses.

[*Concluded*]

[3] "Piping Handbook," by Walker and Crocker, p. 210.

[4] "How to Use Reynolds Numbers in Piping Calculations," by Max W. Benjamin. Heating, Piping and Air Conditioning, November, 1935, pp. 519-523.

Why Cleaning's a Function of Air Conditioning

About the matter of cleaning air. I hold in my hand a bottle filled to the cork with black, greasy dirt which has just been filtered out of the air of the upper east side residential district of Manhattan, the best living section in New York. It is a tiny part of the grand total of 462 tons of dirt which hangs suspended in the atmosphere above New York City. Last week the New York meteorological observatory reported that the air just now is much cleaner than it has been, and that the dust content is down to 1.12 tons per cubic mile over New York. That makes 345 tons above the whole city. But, said this same report, on September 2 the pollution reached the high point of 3.31 tons per cubic mile, or 1,019 tons for the city. This makes for pleasant breathing, does it not? And New York, mind you, is not worse than the average big community in this respect.

Content of Dirt in Air

You will like to know the contents of this dirt. The sample has been analyzed and shown to contain everything, including hair from the neighbor's dog. It has in it tarry oil, petroleum, wood products, chlorides, sulphates, salt, iron, silica and silicates, ammonia, coke carbon, rock fragments, plaster and other building materials, fibers of wool and hair and cotton.

Perhaps the most startling thing in this dirt are the fragments of steel which appear to have come from railroad tracks. The analyst made this statement without knowing where the dirt had been collected. As a matter of fact, it was collected in a private home within a half block of the elevated railroad.—J. J. Donovan.*

*Manager, General Electric Air Conditioning Department, before the *International Association of Sales Executives, Inc.*, meeting in New York City, October 16.

How to Avoid Trouble from Noise in Air Conditioning Installations

Among the factors that must be considered in the design and installation of air conditioning systems and equipment is noise; air conditioning specifications calling for noise levels below a specified value are becoming more and more common . . . . . P. H. Geiger* explains here methods of specifying loudness and loudness level, compares various scales for measuring noise, and discusses grille noise and the influence of surroundings on permissible noise caused by air conditioning equipment . . . . . This practical article is addressed particularly to the installer

ARCHITECTS' specifications calling for noise levels below a specified value are becoming more and more common. The object of this article is to present information enabling design of an air conditioning installation satisfactory from the noise viewpoint.

The common idea that there is a certain air velocity which if exceeded will greatly increase noise is wrong. The truth is that very low velocities produce noise, which increases more or less regularly as the velocity increases. For bedrooms in a quiet district, or for high grade broadcasting studios, very low velocities are required, whereas for other locations much higher velocities can be used without making sufficient noise to be heard over the other noises already existing in the room. If one should set a value of velocity which would be satisfactory for any installation, he would find even then that all of his difficulties were not solved, for different types of grilles make different amounts of noise for the same velocity.

Method of Specifying Loudness

There are several ways by which the loudness of sounds is specified. The most convenient scale to use for making computations is the *American Standards Association* loudness level scale. This is a decibel (db) scale, and is the only decibel scale officially recognized. Although it is simple to use in making computations, it does not, in some ways, present true comparisons between sounds.[1] For example, if one noise has a loudness level of 100 db, a noise which most people will declare to be half as loud, will have a rating of 90 db instead of 50 db as might be expected.

When it is desired to compare the loudness of two sounds it is preferable to use another scale, such as the *A.S.A.* loudness scale,[2] for this scale rates noises as they are heard. The advantage of the *A.S.A.* loudness scale over the decibel scale may be seen by the following example: The noise inside the body of a certain quiet, high priced car may be compared with the noise of a low priced car. Anyone riding in these two cars could not fail to note the great difference, yet, at 50 mph one measured 76.5 db and the other 84.2 db. The difference between 76.5 db and 84.2 db does not sound very striking to one unacquainted with the decibel scale, but when the loudness values are given as 13,000 and 23,500, as they are expressed on the loudness scale, one gets a better impression of the difference.

In order to give an idea of the loudness level (decibel) scale and the loudness scale, Fig. 1 has been prepared. The location of the zero values of two other decibel scales which were used extensively before the present scale was officially adopted, are shown on the chart. These values will enable one to change from one of the old decibel scales

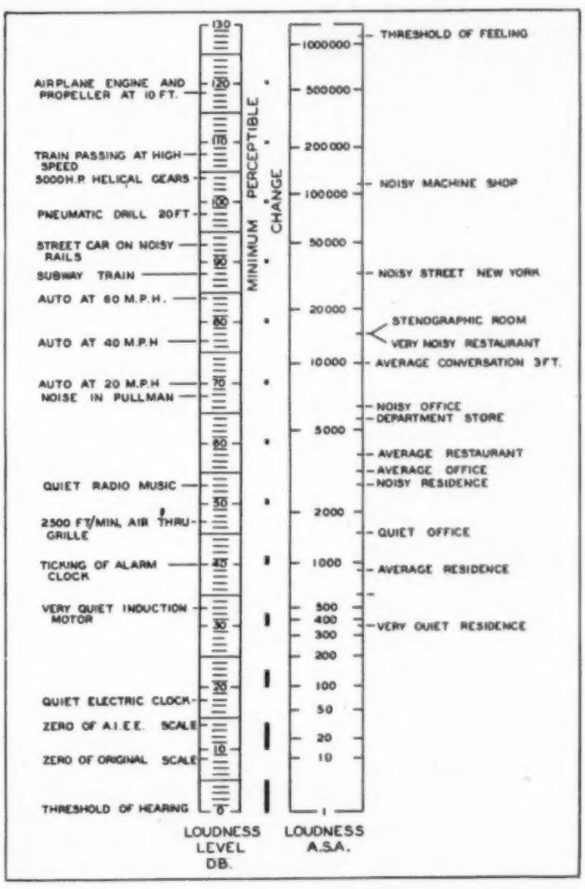


Fig. 1—Comparison of loudness level and loudness scales. The short line segments in the center show the smallest change in loudness which can be perceived

*Research Physicist, Department of Engineering Research, University of Michigan, Ann Arbor, Mich.

[1] Geiger and Firestone, "Estimation of Fractional Loudness," *Journal, Acoustical Society of America*, Vol. V, No. 1, p. 25.

[2] The loudness level scale is a decibel scale; the loudness scale is not. *A. S. A.* committee report. *Journal, Acoustical Society of America.* Vol. V, No. 2, p. 109.

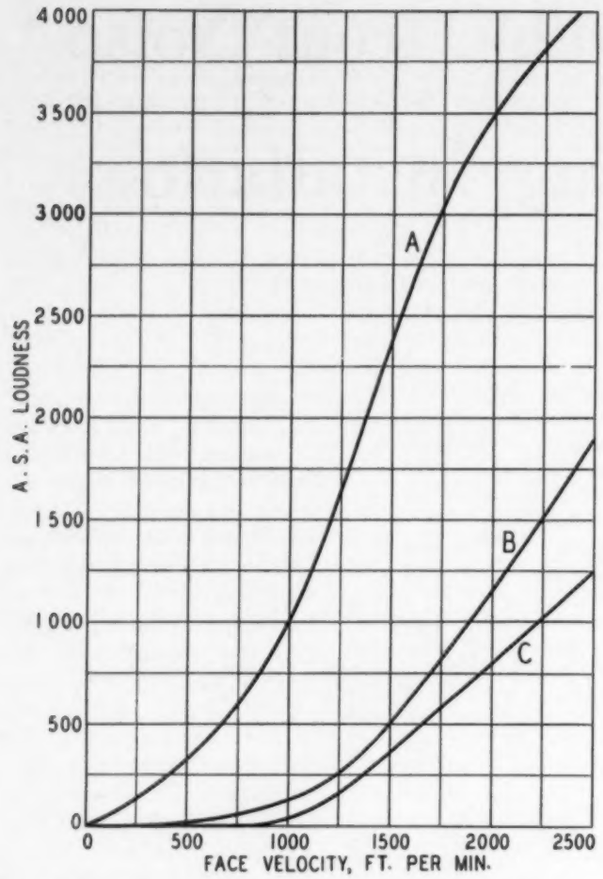


Fig. 2—Comparison of loudness of three grilles *A*, vertical fins placed to give large spread. *B*, honeycomb type giving small spread. *C*, plain perforated.

to the new, official scale, for it is only necessary to add the value shown on the chart to the value one wishes to convert. The heavy line segments in the center of the chart represent the least change in loudness which can be detected by the average person under the best of conditions. It will be seen that a change of 5 db is barely perceptible for very low noise levels, whereas a change of about 0.3 db is noticeable for noise levels of 80 db or over.

Noise of Air Through Grilles

Fig. 2 shows how the noise made by air passing through three typical types of grilles varies with velocity.[3] The *A.S.A.* loudness scale was used for this curve in order to bring out the differences between different grilles. Grille *A* was a type equipped with vertical fins, placed to give a large spread. Grille *B* was a honeycomb type giving a small spread. Grille *C* was a plain perforated grille, such as often used for return air intakes. Fig. 1 demonstrates why it is not possible to set a definite upper limit to the velocity, for a grille like *C* will permit the use of a velocity over double that of a grille like *A* for the same amount of noise.

The data of Fig. 2 are plotted in Fig. 3 in terms of decibels. These curves furnish the basis for computing the loudness produced by any velocity of air, through any size grille, in any room.

The three curves of Fig. 3 may be considered typical of the three types of grilles described, but since grilles of different manufacture, even with very similar air throw patterns, produce different amounts of noise, it will be necessary to obtain data from the grille manufacturer if accurate estimates of noise are required.

Correcting for Different Size Grilles

The curves of Fig. 3 are for grilles having an area of ½ sq ft. To find the loudness level (that is, the decibel rating) of grilles having other areas, Fig. 4 may be used. This curve[4] gives the number of decibels to be added or subtracted from the value obtained from Fig. 3, or a similar curve supplied by the grille manufacturer.

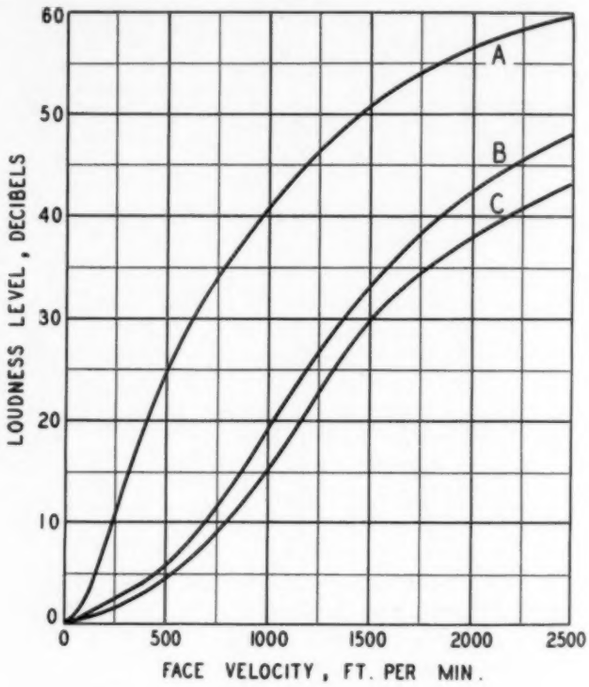


Fig. 3—Loudness level of three grilles, plotted from data of Fig. 2

Fig. 4 shows that each time the grille area is doubled, the grille noise increases by 3 db. The noise of a grille of 1 sq ft area is 3 db greater than that of a grille of ½ sq ft; 2 sq ft is 6 db greater; 4 sq ft is 9 db greater; and so on.

Fig. 4 is plotted on the basis that the velocity is the same through the grilles, regardless of their size. That is, the loudness level of a large grille is greater than that of a grille of ½ sq ft area, *with the same velocity*, by the amount of the correction given by Fig. 4. The statements in the preceding paragraph therefore hold true only when the same velocity air flows through the different size grilles. Of course, if the grille area is increased and the volume flow of air is kept constant, the velocity will be lessened and the noise also. For example, consider a grille like *B*, Fig. 3. For a grille of ½ sq ft area

[3]The data given in Figs. 2 and 3 were selected from a large number of curves obtained in a study of grille noise made by the Physics Division of the Department of Engineering Research at the University of Michigan. This work was sponsored by the Hart and Cooley Mfg. Co., whose consent has been given to the publication of this paper.

[4]The equation for the correction curve is given by the relation

$$\text{Correction} = \log_{10}(A/0.5)$$

where A is the area of the grille in sq ft.

and a velocity of 2,000 fpm, the loudness level (by Fig. 3) is 42.5 db. If the area of the grille were increased to 1 sq ft and the volume flow kept the same, the velocity would be reduced to 1,000 fpm. The loudness level of a ½ sq ft grille at 1,000 fpm is, from Fig. 3, 19 db. Applying the correction for area as given by Fig. 4, it will be seen that the 1 sq ft grille at this velocity will have a loudness level of 22 db.

The figures above show that the noise level decreases rather rapidly as the size of a grille is increased, provided that the total amount of air flowing remains the same. The same fact is shown in Fig. 5, where the loudness level of grille noise is shown for different size grilles. The volume air flow, in cfm, for each of the curves is shown. The figures apply to a Type *B* grille, but they may be considered as typical of most grilles.

If more than one inlet grille is used in a room, the noise may be computed as if only one grille were to be used, with an area equal to the sum of the areas of the separate grilles. Since the velocities used for the return air intake grilles are usually lower than the input grilles, their noise need not be considered.

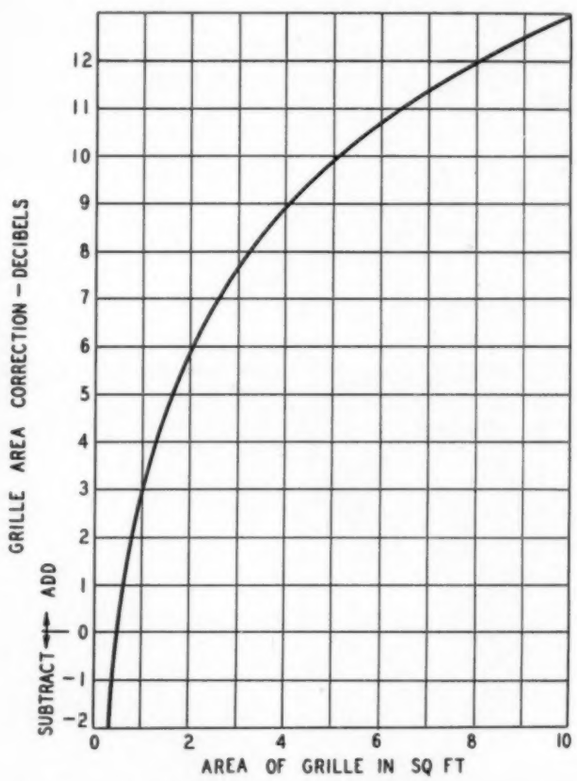


Fig. 4—Corrections to apply to Fig. 3 for grilles of different areas

Influence of Surroundings On Noise

Since sound is absorbed in varying amounts by different surfaces, the noise made by air flowing through a grille will be different in different rooms. If the room has hard plaster walls and ceiling, tile floors and no rugs, draperies, or upholstered furniture, the noise will be much greater than it will in a room having thick rugs, heavily upholstered furniture, and heavy draperies, for in the latter case the sound is absorbed by the porous surfaces. The following paragraphs tell how to determine how much the noise of a grille, as given by Fig. 3, is changed in different rooms.

Table 1—Sound Absorption Coefficients

Material	Sound Absorption Coefficient
Carpet	0.20
Rugs	0.30
Linoleum	0.03
Wood, flooring or paneling	0.03
Ordinary plaster	0.03
Brick wall	0.02
Draperies, light weight	0.10
Draperies, heavy	0.40
Glass	0.02
	Sound Absorption Units
Person, each	4
Chair, large, heavily upholstered	6
Upholstered davenport, each	10
Plain wood chair, each	0.2

The data used in plotting Fig. 3 apply to the average living room. Since the correction to be applied is not very large for ordinary rooms it will not be necessary to correct the values given in Fig. 3 unless quite accurate estimates are required. However, for special cases, such as broadcasting studios, it may be desirable to make the corrections.

In order to correct for the sound absorbing qualities of a room and its contents, it is necessary to know how many sound absorbing units there are in the room. The number of sound absorption units in any surface is equal to the area in square feet of that surface multiplied by the sound absorption coefficient for that surface. The sound absorption coefficients of some common materials are given in Table 1. The coefficients of other materials may be found in handbooks. An especially complete list is included in Knudsen's "Architectural Acoustics."[6]

[6]Published by John Wiley & Sons, Inc., New York, N. Y.

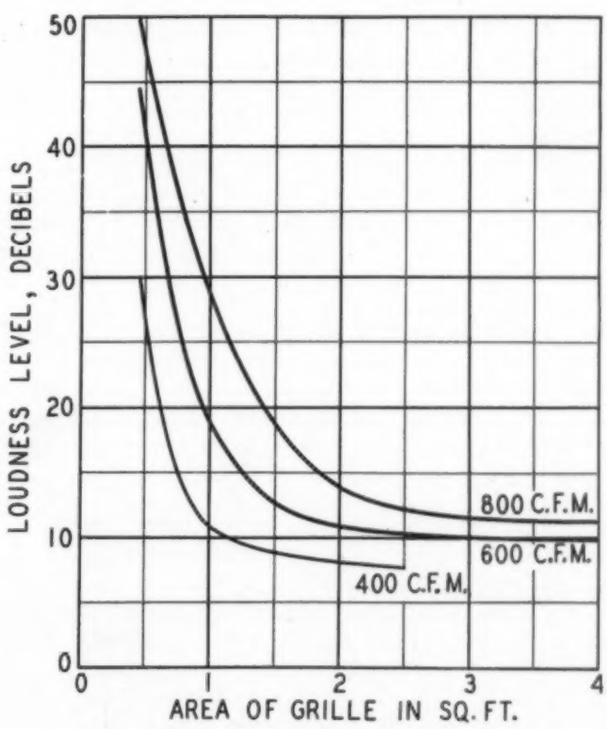


Fig. 5 — Change in loudness level for given volume of air flow through different size grilles

The total number of sound absorption units in the room is the sum of all the units obtained for each surface. If a floor is covered partially by a rug, the portion of the floor under the rug is not included in the calculation. The computations do not need to be made with any great accuracy; rough approximations are sufficient.

When the number of absorption units is computed, the value to be added to or subtracted from the noise value as given by Fig. 3 is obtained from Fig. 6.[6]

Other Considerations

Tests on grilles equipped with valves show that a single shutter valve is quieter than a multi-shutter valve. The location of the grille in a room is not of much importance from the viewpoint of the noise it makes. When the flow of air through a grille is not uniform, the noise is somewhat greater than the value given by Fig. 3.

A second article will discuss the permissible amount of noise in various buildings and rooms. Also suggestions will be given for reducing the noise made by air conditioning equipment other than grilles.

[6]Fig. 6 is computed from the relation

$$\text{Decibels Correction} = 10 \log_{10} (a/100)$$

where a is the number of absorption units in the room. The values of Fig. 3 apply to a room with 100 absorption units.

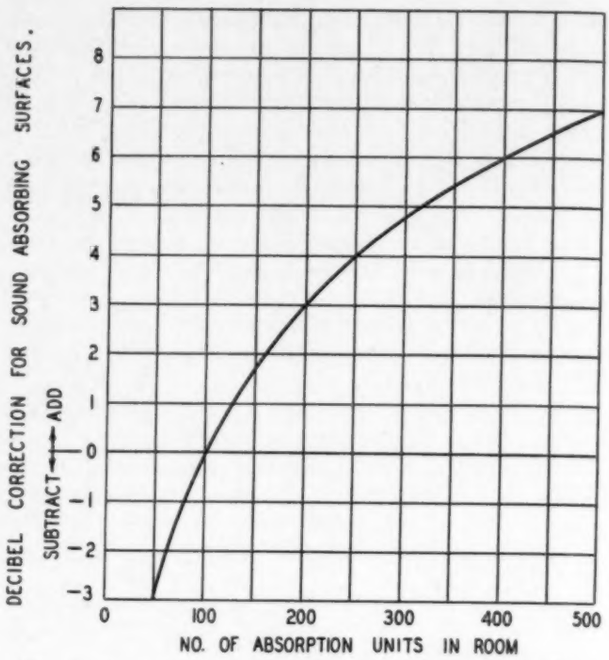


Fig. 6—Corrections to apply to Fig. 3 for changes in loudness due to the acoustic characteristics of different rooms

Absorption Refrigeration Unit—

[*Concluded from page 590*]

creasing the effectiveness of the unit, the water can be permitted to rise in temperature to 105 F before leaving the rectifier. Ammonia and aqua comprise the refrigerant-solvent, but certain other refrigerant-solvents could be used.

The two air conditioners, of conventional design, have steam coils for winter operation and brine coils for summer cooling. The one serving the main lower floor has a capacity of 6000 cfm and delivers air into riser ducts feeding horizontal ducts. Air is introduced to the rooms through slotted grilles slightly below ceiling level, and is returned to the conditioner through floor grilles and ducts. A thermostat controls the amount of return air bypassing the cooling coils. Outside air is manually adjusted by dampers for normal operation and does not require much further change except seasonally. Humidity is controlled principally by manual setting of the rate of brine flow through the cooling coils and by tempering the cold brine by recirculating part of the warmer brine. Air from the kitchen and toilets is removed by an exhaust fan.

The other conditioner, which is situated in the attic, has a capacity of 2000 cfm and serves the second floor; its operation is similar to the main floor conditioner. Air enters each bedroom through a slotted grille and leaves through louvres built in the lower part of the door of the room.

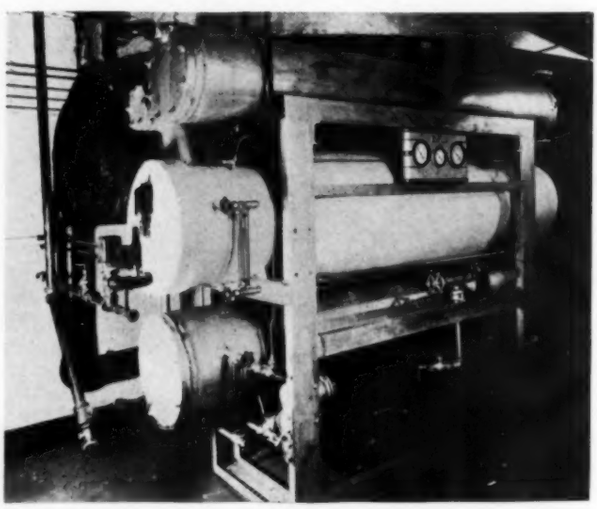


Fig. 3—The refrigeration unit

In winter the same equipment is utilized, except that the steam coils in the conditioner instead of the brine coils are employed and a separate humidifier properly conditions the delivered air.

This installation was made in 1935 and has performed exceptionally well during the very cold temperatures of last winter and the record-breaking hot weather of the summer of 1936. Operating costs (in this case, preponderantly fuel costs) and initial costs have been found to be reasonable.

Strength and Design of Covers and Flanges for Pressure Vessels and Piping

[Part 1]

By T. McLean Jasper*, H. Gregersen*, and A. M. Zoellner*

THE construction of a vessel or pipe line for high pressure service involves a balance in the design at every point so that the safety of such equipment can be assured.

Previous investigations have established the necessity for and the required amount of reinforcement for openings in vessel walls and for the proper shapes of heads of vessels. The present investigation aims to go into the question of covers and flanges of openings.

For the determination of the strength of covers and flanges various theories and formulas have been developed. With regard to the application of these theories and formulas previous investigations have established their reliability for covers and rings. In the matter of hubbed flanges considerable mis-application of the theory has existed, with the result that stress analysis has occasionally been applied at points far removed from where the maximum stress occurs, and the result has been a confused system for the design of hubbed flanges.

This investigation aims to establish rational methods for the design of covers and flanges. A large number of ring and hubbed flanges have been tested with regard to strength and the test results compared with theoretical calculations obtained from various formulas. The appropriate formulas to be used in the design of covers, and ring and hubbed flanges, are given in forms convenient for engineering purposes.

Early in the investigation it became apparent that for hubbed flanges no provision was made in the various formulas for the effect of fillets at the junction between the flange and hub, and this question has formed a major division in this investigation.

The question of bolt loads and the requirements of the balance between the bolt sizes, materials used for bolts, the tightening of bolts, and the desirability that bolts shall fail under careless tightening loads rather than the more expensive flanges have also been considered.

This report will therefore consider (1) covers, (2) ring flanges, (3) hubbed flanges, and (4) bolt loads.

1. COVERS

The longitudinal section of a cover with the forces acting on it is shown in Fig. 1.

The equation of equilibrium is:

$$W = G + \frac{\pi}{4} g^2 p \quad \ldots\ldots [1]$$

The maximum stress will be the bending stress at the center of the plate. The most precise formula[1] for this stress is:

$$S = \frac{3}{\pi T^2}\left[\frac{1+\mu}{16}\pi g^2 p + \frac{1-\mu}{32}\frac{8G(b^2-g^2)+\pi g^2 p(2b^2-g^2)}{D^2} + \frac{1+\mu}{8}(4G+\pi g^2 p)\log_e \frac{b}{g}\right] \quad \ldots [2]$$

Assuming Poisson's ratio[2] $\mu = 0.25$ and substituting for the natural logarithm the common logarithm,[3] Formula 2 can be written:

$$S = \frac{1}{T^2}\left[0.2344\, g^2 p + 0.0703\frac{2.55\,G(b^2-g^2)+g^2 p(2b^2-g^2)}{D^2} + 1.078\,(1.274G + g^2 p)\log_{10}\frac{b}{g}\right] \quad \ldots [2a]$$

Formula 2a is rather complicated for practical use and it is customary to use the more simple formula for uniformly loaded plates with simply supported edge as shown schematically in Fig 2.

The equation of equilibrium is:

*Research Engineer, A. O. Smith Corp., Milwaukee, Wis.

Illustrations reproduced by courtesy of the A. O. Smith Corp.

This paper was presented at the annual meeting of the *American Society of Mechanical Engineers*, December, 1934, New York, N. Y., but has not heretofore been available in published form.

[1]Formula 2 was developed by K. Axelson, Engineer, A. O. Smith Corp.

[2]Determination of Poisson's Ratio. *Proceedings, American Society for Testing Materials*, Vol. 24, Part II, 1924.

[3]$\log_e x = 2.3026 \log_{10} x$.

Flanges and covers are subject to the same stresses in pipe line service as in vessel openings; therefore the investigation by Jasper, Gregersen and Zoellner is a contribution to better piping design no less than to improved design of heat exchangers, pressure vessels, etc.

The investigation is based upon extensive strength tests of rings and hubbed flanges. Test results have been compared with values computed by use of various formulas. Questions such as bolt materials and stresses, with their relation to flange strength; the effects of fillets at the junction of flange and hub; the most favorable location of the gasket; the effects of ignorant tightening, have all been analyzed.

This paper is of great value in the solution of problems which perplex many engineers today.—F. E. WERTHEIM.

$$W = \frac{\pi}{4} D^2 p \quad \ldots\ldots [3]$$

The maximum stress will be the bending stress at the center of the plate and the most precise formula[4] for this stress is:

$$S = \frac{3(3+\mu)}{32} - \frac{pD^2}{T^2} \quad \ldots\ldots [4]$$

Assuming Poisson's ratio[2] $\mu = 0.25$, Formula 4 can be written:

$$S = 0.305 \frac{pD^2}{T^2} \quad \ldots\ldots [4a]$$

It may be of interest to note that Fig. 1 is converted into Fig. 2 when assuming $b = D$, $g = D$, and $G = 0$. Consequently the same assumptions inserted in Formula 2 results in Formula 4. Furthermore, both formulas can be solved for thickness as well as for stress which is of great importance in design where the question is to determine the thickness corresponding to an assumed working stress.

Applications of the precise Formula 2a and the Formula 4a for plates with simply supported edge show that when b is inserted instead of D in Formula 4a the two formulas give approximately the same result. Thus it can be concluded that the simple Formula 4a is accurate enough for design purposes. The application of the simple Formula 4a is also justified, the more so because an accurate determination of the gasket load is generally impossible.

2. RING FLANGES

The longitudinal section of a ring flange with the forces acting on it is shown in Fig. 3.

The equation of equilibrium is:

$$W = G \quad \ldots\ldots [5]$$

The maximum stress will be the tangential stress at the inner edges of the ring section. For this stress the following three formulas have been developed.

Formula by Holmberg-Axelson:[5]

$$S = \frac{3}{2\pi} \frac{W}{T^2(D^2-d^2)} \left[(1-\mu)\ (b^2-g^2) + 2(1+\mu) D^2 \log_e \frac{b}{g} \right] \ldots [6]$$

Assuming Poisson's ratio[2] $\mu = 0.25$ and substituting for the natural logarithm the common logarithm,[3] Formula 6 can be written:

$$S = \frac{0.3583\, W}{T^2(D^2-d^2)} \left[(b^2-g^2) + 7.675\, D^2 \log_{10} \frac{b}{g} \right] \ldots\ldots [6a]$$

Formula 6 is based on the general plate theory and is valid for all possible dimensions (except when $d = 0$ in which case we have a cover for which the appropriate cover formula should be used).

Formula by Waters:[6]

$$S = \frac{3}{\pi} \frac{Wa}{T^2(D-d)} \left[2(1+\mu) \frac{D^2 \log_e D/d}{D^2-d^2} + (1-\mu) \right] \ldots\ldots [7]$$

Assuming Poisson's ratio[2] $\mu = 0.25$ and substituting for the natural logarithm the common logarithm[3] Formula 7 can be written,[7]

$$S = \frac{5.5\, Wa}{T^2(D-d)} \left[\frac{D^2 \log_{10} D/d}{D^2-d^2} + 0.1304 \right] \ldots\ldots [7a]$$

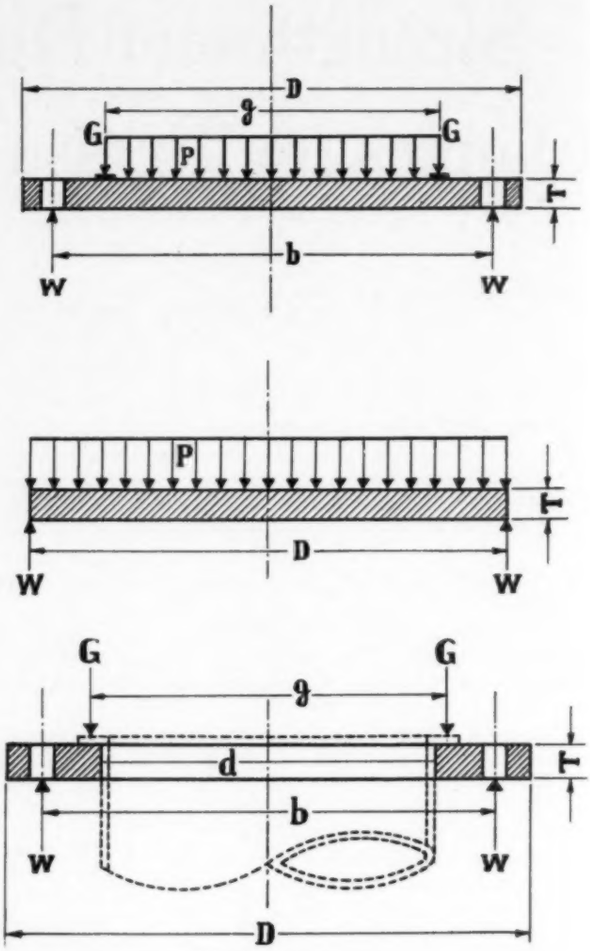
[4]See "Strength of Materials," by S. Timoshenko, Part 2, 1930.

[5]"Analysis of Stresses in Circular Plates and Rings," by E. O. Holmberg and Karl Axelson. *Transactions, American Society of Mechanical Engineers* (Applied Mechanics). Vol. 54, No. 2, 1932.

[6]"The Strength of Pipe Flanges," by O. E. Waters and J. Hall Taylor. *Mechanical Engineering*, May, 1927, page 531.

[7]Waters, in his derivation of the practical formulas, assumed Poisson's ratio as 0.3, resulting in:

$$S = \frac{5.72 Wa}{T^2 (D-d)} \left(\frac{D^2 \log_{10} D/d}{D^2-d^2} + 0.117 \right)$$



***Top to bottom*: Fig. 1—Longitudinal section of a cover with the forces acting on it. . . . Fig. 2—Uniformly loaded plate with simply supported edge. . . . Fig. 3—Longitudinal section of ring flange with forces acting on it**

Formula 7 is based on the general plate theory. In its development accuracy has been somewhat sacrificed for the sake of simplicity, thus the formula contains the variable a, instead of the two variables b and g which permits a direct comparison between the maximum stress S and the external moment Wa for given dimensions. The conversion of Holmberg-Axelson's formula into Waters formula will be given in Appendix 5.

Formula by Timoshenko:[8]

$$S = \frac{6Wa}{\pi T^2 d \log_e D/d} \quad \ldots\ldots [8]$$

Substituting for the natural logarithm the common logarithm,[3] Formula 8 can be written:

$$S = \frac{Wa}{1.205\, T^2 d \log_{10} D/d} \quad \ldots\ldots [8a]$$

Formula 8 has been based on the theory of deformation symmetrical about axes.[4] It is extremely simple and practical for engineering use.

The above formulas, designated 6 — 8a for the strength of ring flanges, all have the particular advantage that they can be solved for flange thickness as well as for stress.

[8]"Methods of Determining the Strength of Pipe Flanges," *Mechanical Engineering*, December 1927, p. 1340.

List of Symbols Used

W—Total bolt load
G—Gasket load
D—Outside diameter of cover, ring, or flange
T—Thickness of cover, ring, or flange
S—Stress
S_r—Modulus of rupture
$M = Wa$—External moment applied or assumed in design
M_o—Moment per unit length of circumference
Q—Force
Q_o—Shearing force per unit length of circumference
M_{test}—Moment applied in test samples at failure
S_{test}—Stress obtained in test samples at failure
b—Bolt circle diameter
g—Gasket diameter
d—Inside diameter of flange or ring opening
a—Distance between gasket and bolt circle
a_o—Distance from bolt circle to center of hub thickness in a hubbed flange
d_m—Mean diameter of hub in a hubbed flange
t—Thickness of hub in a hubbed flange
μ—Poisson's ratio

Comparison between the Results obtained from Formulas and Test Flanges

In the following figures the above formulas for ring flanges have been plotted for comparison and test results are shown on the plot in order to establish the relative value and accuracy of the formulas.

With regard to test materials it would seem logical to use low carbon steel, which is the material ordinarily used in flanges. Since, however, the production and machining of a large number of steel flanges for test purposes involves considerable expenditures, and the testing of steel flanges involves difficulties with regard to the detection of the yield point (particularly when the maximum stress takes place in a small portion of the body tested), it was decided to use plaster of paris as the test material. A description of the physical properties of plaster of paris will be given in Appendix 2. It is appropriate to state that plaster of paris is an ideal material for checking formulas based on the general theory of elasticity because it follows Hooke's law up to its ultimate strength. Furthermore, it is inexpensive and fairly easy to cast and machine when the castings are not too large or complex.

The test arrangement will be described in Appendix 1. It is appropriate to state that the principle employed in all of the tests has been to vary one flange dimension at a time while keeping the other dimensions constant. The external moments required to fracture the flanges have been plotted against the various dimensions.

On account of the possible large difference between the material strength of the test flanges it was necessary to reduce the external moment required to fracture the test flanges to a basic value in order to be able to compare the test results. Since the average tensile strength of a large number of specimens of the test material happened to be 318 lb per sq in., this value has been taken as the basic tensile strength. The reduction of the external moment $M = Wa$ has been made according to the relation:

$$M = \frac{318}{S_{test}} M_{test} \quad [9]$$

where:

318 = basic tensile strength in lb per sq in.
S_{test} = tensile strength of casting obtained from test specimens.
M_{test} = external moment required to fracture the test flange.
M = external moment corresponding to the basic tensile strength of 318 lb per sq in.

The same basic tensile strength has been used in the theoretical formulas, thus permitting a comparison between theoretical curves and test results.

Variation of External Moment with Flange Thickness

In designing ring flanges, engineers are mostly concerned about the variation in strength with flange thickness for given inside and outside flange diameters. Figs. 4 and 5 show the effect of the variation of external moment with flange thickness according to the above formulas for smaller and larger ring flanges respectively. They also show the test results for the above conditions.

Complete information with regard to flange dimensions, basic tensile strength, and the representations of curves and test results are given on each graph. A tabulation of the test results and photographs of fractured ring flanges will be given in Appendix 2. From Figs. 4 and 5 it can be seen that the conformity between the theoretical curves is very good, and that the test results check closely with the theoretical curves.

As can be seen from all graphs the test results show slightly higher values for the external moment than the theoretical curves.

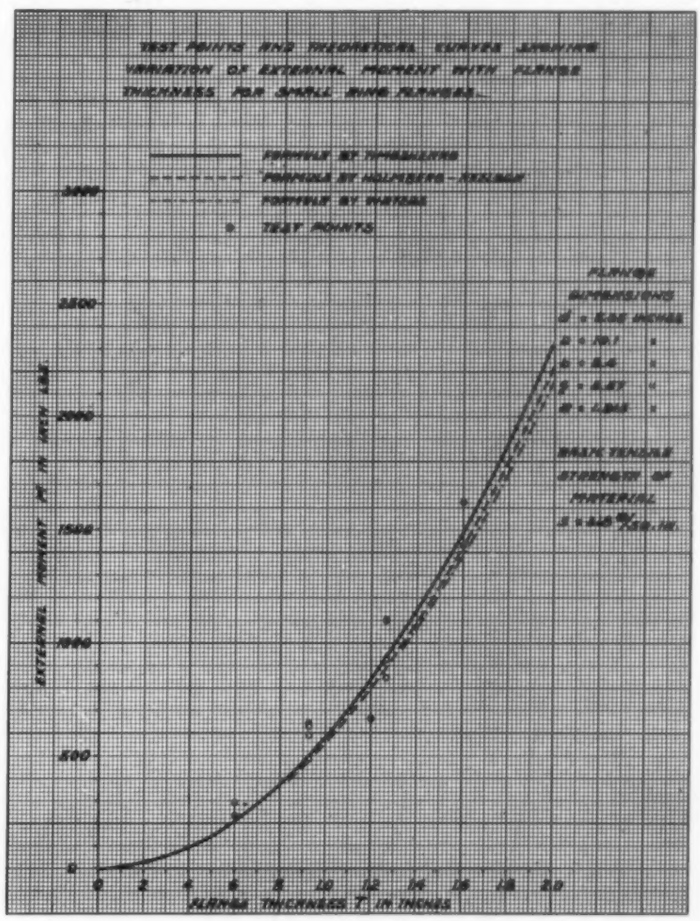

TEST POINTS AND THEORETICAL CURVES SHOWING VARIATION OF EXTERNAL MOMENT WITH FLANGE THICKNESS FOR SMALL RING FLANGES
FORMULA BY TIMOSHENKO
FORMULA BY GRASHOF-ZEUNER
FORMULA BY WATSON
TEST POINTS
FLANGE DIMENSIONS
BASIC TENSILE STRENGTH OF MATERIAL
EXTERNAL MOMENT IN INCH LBS.
FLANGE THICKNESS T IN INCHES

Fig. 4—Test points and theoretical curves showing variation of external moment with flange thickness for small ring flanges
Flange dimensions—d, 5.05 in.; D, 10.1 in.; b, 9.4 in.; g, 5.57 in.; a, 1.915 in. Basic strength of material, S, 318 lb. per sq. in.

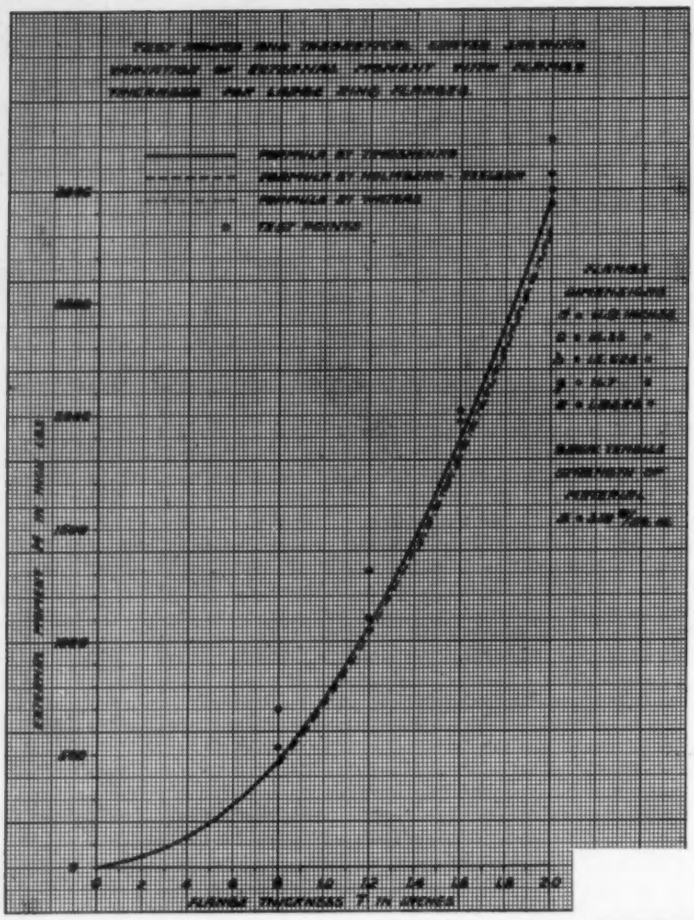


Fig. 5 (above)—Test points and theoretical curves showing variation of external moment with flange thickness for large ring flanges

Flange dimensions—*d*, 11.9 in.; *D*, 16.35 in.; *b*, 15.625 in.; *g*, 11.7 in.; *a*, 1.9625 in. Basic strength of material, *S*, 318 lb per sq in.

Fig. 6 (right)—Test points and theoretical curves showing variation of external moment with flange width for small ring flanges

Flange dimensions—*d*, 5.05 in.; *T*, 1.4 in.; *g*, 5.57 in.; *D*—*b*, 0.7 in. Basic strength of material, *S*, 318 lb per sq in.

The main reason for this is believed to be that the theoretical curves are based on the strength of the test material, whereas the flanges break in bending. As is generally known most materials have a higher calculated strength in bending (modulus of rupture) than in tension (tensile strength), the ratio between them depending on the shape of the section fractured in bending. From a large number of tensile and bend tests, the ratio between modulus of rupture and tensile strength for plaster of paris was found to be about 1.2 for the particular shape of bending specimens investigated. These tests will be described in Appendix 2.

Variation of External Moment with Flange Width

In designing ring flanges, engineers may be concerned about the variation in strength with the outside flange diameter (or flange width) for given inside flange diameter and flange thickness. In other words: Does it pay to make the diameter of the bolt circle small resulting in flanges with small flange width or *vice versa*?

Fig. 6 shows the variation of external moment with the outside flange diameter (or flange width) according to the above formulas and tests. In the investigation the bolt circle and the outside diameter of the flange was reduced or increased by the same amount. It is of interest to note that the strength of ring flanges increases with the outside flange diameter even when the diameter of the bolt circle is increased the same amount as the outside flange diameter.

Since the strength of ring flanges increases much faster with the flange thickness than with the flange width, the most economical design is evidently flanges with small flange width and large flange thickness.

Summary

As a summary of this investigation of ring flanges it can be stated that:

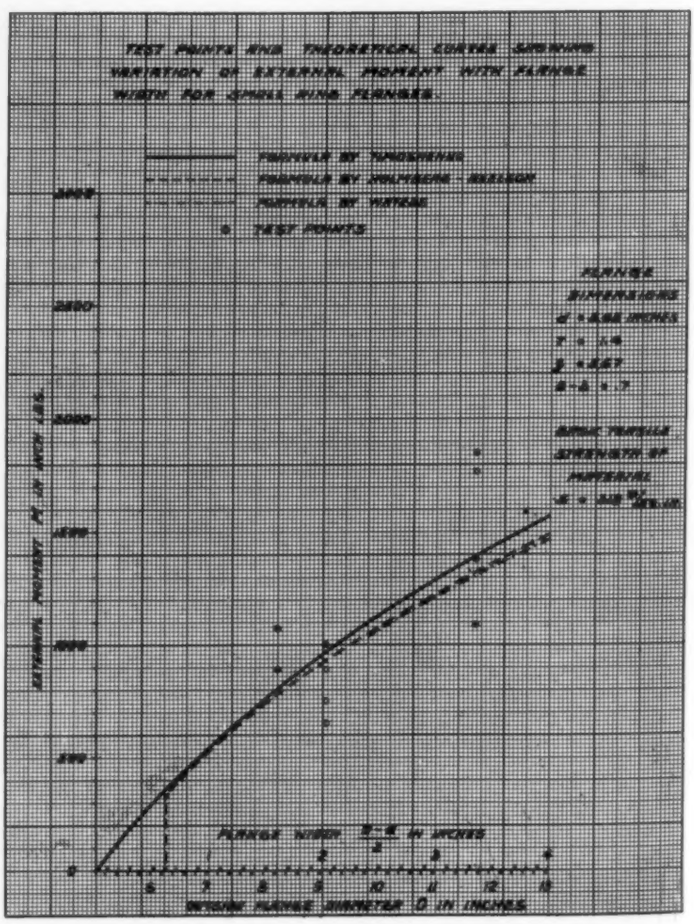
1. The formulas given are all reliable for design purposes.

Keeping rigidly to the theory of elasticity it might be said that the Holmberg-Axelson formula is precise in its development. The Waters formula is almost identical and is made more simple by assuming that the loads act at the edges. The Timoshenko formula is extremely simple and a study of the curves discloses that it is well within the degree of accuracy which engineers expect from tests.

Evidently the formulas can be used with the same accuracy in the determination of the stress for given external load and dimensions since the stress is directly proportional to the external load.

2. Plaster of paris is a reliable material for checking formulas based on the general theories in material strength. Thus we may use it in checking the theories and formulas pertaining to the more complicated problem of hubbed flanges dealt with in the subsequent chapter.

[*To be continued*]



Chicago's City Engineer Surveys

Effect of Air Conditioning Demand on City Water Supply and Sewer Systems

IN attempting to picture the air conditioning problem in the Chicago loop area and its relation to the water supply and the sewers, I shall divide my discussion into four parts: (1) the present and probable future demands upon the water supply system; (2) the ability of the water supply system to meet these demands; (3) the ability of the sewers to carry away the waste water (present and future); and (4) the possible solution of the problem. It should be kept in mind that we are considering only the central business district of Chicago, or the so-called "loop" area bounded on the east by the lake, on the north and west by the Chicago river, and on the south by 12th St.

Present Water Requirements

According to figures supplied by the Commonwealth Edison Co. there were in this area on September 1, 1936, 398 air conditioning installations, with a total refrigerating capacity of 11,865 tons. If we assume a figure of two gpm of water per ton of refrigeration these 398 installations require water at a rate of 23,730 gpm, or a rate of approximately 34,000,000 gal per day. This figure has been checked by tests on existing installations, Table 1.

In order to impress upon you the great increase in the demand for water in the loop area during the past seven years, I should like to call attention to three tests made in the district; one in May, 1929, one in July, 1936, and one in September, 1936.

A survey made from May 9 to 15, 1929, showed a peak rate of flow into this area of 52,000,000 gal per day. Since this survey in 1929 the normal requirement for water in this section has been reduced by the reduction to a minimum of underground street leakage, and by the razing of many buildings. Therefore, under ordinary conditions the normal demand for water in the loop area should be less in 1936 than it was in 1929. But the following test, made in 1936, shows that the demand has increased, and in this connection it should be kept in mind that since the test in 1929 many installations of air conditioning equipment have been made in the area, and no doubt these installations explain the following results.

Flow measurements were made on July 26, 1936, in hot, dry weather, on the feeder mains supplying the area bounded on the north and west by the Chicago river and on the south by 12th St. The observations were made during the hours of maximum demand (noon to 2 p. m.). A rate of 65,000,000 gal per day was recorded, which is higher than ever before observed in this section of the city.

A third test was made on September 28, 1936, after a large rainfall and after extremely high temperatures had abated. This test was made during the hours of maximum demand and showed a rate of flow into the loop area of 39,000,000 gal per day, a reduction of 26,000,000 gal per day when compared to the July, 1936, test.

This test is a fairly good check on the estimate of the amount of water required by the 11,865 tons of air conditioning equipment now installed in the loop. It was stated before that if this equipment were operating at maximum capacity, it would require approximately 34,000,000 gal of water per day. It may have been that during the test of July 26, 1936, the installed air conditioning equipment was not operating at full capacity.

The condensing water requirements of air conditioning plants impose severe demands on municipal water supply and sewer systems; the problem becomes one of increasing importance with the ever-widening use of air conditioning for profit in congested down-town districts. . . . In this thorough and interesting analysis of the Chicago situation, Loran D. Gayton* discusses present and future demands on the water supply system, ability of the system to meet the demands, ability of the sewers to carry away waste water, and possible solutions of the problem. . . . His method of attack should be helpful to those who are concerned with the water supply and water disposal problem in other cities

District Is 16 Per Cent Air Conditioned

The number of persons within the central business district varies according to the hour, the season, the weather and to business and other conditions. Counts made of the number of persons entering and leaving the loop by all means of transportation indicate that the greatest number of people there at one time occurs about 1:30 p. m. These counts, corrected for the slightly greater area under consideration, and for permanent residents, furnish an estimate of approximately 400,000 persons within the central district at the peak of an ordinary working day.

If there were air conditioned space in the central district for every one of the 400,000-odd persons, we might say that this district was 100 per cent air conditioned. To furnish an air conditioned space for one person requires

*Acting City Engineer, City of Chicago. From a paper presented at a meeting of the Illinois Chapter of the *American Society of Heating and Ventilating Engineers*, October 12, 1936.

an average heat removal of 2,300 Btu per hr, whereas a ton of refrigeration is equivalent to 12,000 Btu per hr. Therefore, 5.2 persons may be accommodated with space by each ton of refrigeration. The equipment now installed in the central business district is therefore capable of furnishing air conditioned space to 61,700 people, or, in other words, the area is about 16 per cent air conditioned.

Predicting Future Water Demand

So much for the present demand for water. Now let us consider future probabilities.

Any method of predicting the future of air conditioning and its demands for water is more or less unsatisfactory. We know that the demand is gaining headway, and indications are that the progress will be at an accelerated rate for a number of years.

The saturation point of demand is also difficult, if not impossible, to predict. Certain classes of users are expected to compete between themselves until that particular business cannot succeed without air conditioning. Other classes of business may never require air conditioning to meet competition.

In an attempt to determine the water demand for air conditioning purposes in the future we may resort to several different methods of approximation:

(1) To continue the present trend of installations, adding a certain increment per year, or by extending the curve shown by the rate of past installations.

(2) By supplying air conditioning to a certain maximum per cent of the total floor space or area involved.

(3) By supplying air conditioning to a certain maximum per cent of the number of people involved.

We have used the last method and checked the results within reason by the other two.

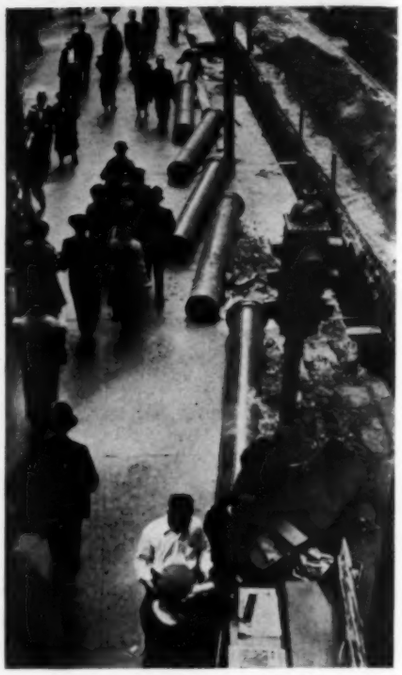
We have assumed that within 20 years there will be an air conditioned space for every person normally in the district, or that the district will be 100 per cent air conditioned at that time. This does not mean that every building will be air conditioned but that some may be fully conditioned, others partly conditioned, and still others not conditioned at all, but that the total of the equipment installed will be sufficient to provide conditioned air for every person.

We have already shown that approximately 400,000 persons are at the present time in the central business district during mid-day and with a normal population increase this number should reach 530,000 persons in the next 20 years.

To provide air conditioned space for this number of people will require about 102,000 tons of refrigeration and demand 204,000 gpm of water. The water demand for air conditioning equipment at that time will be at a rate of 295,000,000 gal per day, requiring pumps, mains and sewers of that additional capacity to furnish water service.

Pumping equipment and piping to supply water at a rate of nearly 300,000,000 gal per day represents a very large investment and operating cost and, due to the few hours in the year during which it is needed, the revenue from this source will be comparatively small.

Fortunately there are means already developed to conserve water by cooling it and returning it for re-use rather than wasting it to the sewers. This equipment may come into use through its own merits in installations where it is possible to show that by its use a saving can be brought about in operating costs. In Chicago, where the cost of water is the lowest of any city in the world, it may be difficult to show savings by the use of such equipment, and such equipment may be somewhat slow in gaining a foothold. If the consumer fails to take the initiative in the installation of water conserving equipment and the demand for water becomes too great to be economically handled it may become necessary to pass legislation limiting the use of water for air conditioning purposes, as has already been done in some cities.



Sixteen inch cast iron service main being installed to supply condensing water to large conditioning system

Available Water Supply

The foregoing indicates that at the present time the air conditioning equipment in the loop area requires a maximum rate of approximately 34,000,000 gal of water per day in addition to the normal requirements of the territory, and the test of July, 1936, indicates that the peak load requirements of the loop area, including the normal demands plus the air conditioning demands, is a rate of approximately 65,000,000 gal per day.

The foregoing study also indicates that in 20 years the loop area may require for air conditioning purposes 295,000,000 gal per day above the normal requirements. Now let us study the present available water supply in this territory as compared to the present and future demand. The loop area is supplied jointly from three pumping stations, the total capacity of the six feeder mains from the three separate stations amounting to 160,000,000 gal per day at ordinary velocities. In case of a fire or any other emergency, these feeder mains could be worked to at least a 50 per cent overload, or in other words, if called upon, we could at the present time deliver water at the rate of 240,000,000 gal per day into the loop area.

This indicates that there is at the present time available to the loop area over three and one-half times the peak load demands for water, including the present installations of air conditioning equipment. The indications are that the water now available to the loop area is sufficient to meet all demands for the next ten years.

As to the future, plans have been projected to increase the capacity of the grid of the loop area by laying 20, 16, and 12 in. pipes in a number of streets where smaller pipes now serve the present needs. The time of laying

Another view of cast iron water supply main being put in on busy Chicago street

these grid mains will of course be determined by future requirements.

The first section of this paper indicates that at present the air conditioning equipment installed in the central business district of Chicago, which equipment uses no water conserving devices but demands a maximum supply of water for cooling purposes and then wastes this water directly to the sewers when operated at maximum capacity, requires a rate of approximately 34,000,000 gal per day. The first part of the paper also indicates that within 20 years this demand for water, providing no water conserving devices are installed, may amount to as much as 295,000,000 gal of water per day. Next, it is indicated that at the present time there is available to the loop area at least 240,000,000 gal per day, and that this amount of water will take care of all demands in the loop area for at least ten years to come.

Loop Sewer System as Related to Air Conditioning

I shall now attempt to picture the ability of the sewers in the area to take and dispose of all the waste water from the district under consideration. In order that you may have a proper perspective as regards the sewers in the loop area, I shall give you a little history.

The city council of Chicago, on January 24, 1910, passed a resolution directing the board of local improvements to investigate fully the needs in the matter of the sewers of the district bounded by the river, the lake and 12th St., and to make report thereof to the council. Much of the material that follows was taken from that report, which was made by C. D. Hill, at that time superintendent of the bureau of sewers and considered an authority on sewer design and construction.

The sewers in the present central business district of the city were designed and built between 1855 and 1860 under the direction of Ellis S. Chesbrough, then city engineer. Mr. Chesbrough is regarded by those who know of his work as being one of the greatest engineers ever developed in this country. In addition to the original Chicago sewer system, he was responsible for the design and construction of the original two-mile crib and tunnel, and the Chicago Ave. pumping station, which were completed and put in operation in 1867.

The sewers in the district under consideration were designed on a liberal scale to provide for the storm water run-off that was to be expected, and proved sufficient for the conditions met during the following 25 years. During that period there were no skyscraper buildings. The pavements of the streets were not impervious. There were considerable areas of private land not roofed or paved, and there was no serious difficulty in draining the streets and the buildings. The conditions of today with large buildings, impervious pavements and private property nearly all covered with either roofs or paved areas, require a capacity much larger than these sewers possess. With the conditions that we will have ultimately, the sewers should have a capacity of about five times the capacity of the present sewers.

Please keep in mind that the foregoing was written in 1911.

The report of 1911 in general stated that the sewers were of insufficient size, that they had been badly damaged by the construction of buildings and other structures, that they were not self-cleaning, and that it was practically impossible to keep them clean.

The report made the following recommendation:

"The more this problem is studied, the less possible it seems that we will be able to use any of the present sewers. A system of relief sewers, giving additional outlets to the main sewers, will not be sufficient for the reason that the greatest trouble is from the small lateral sewers. The entire sewer system should be condemned and replaced with an entirely new system that will be completely up to date and will take care of all future possible developments of the district."

The report also stated that the reconstruction of these sewers should have been commenced years ago, but that it was impossible to make any definite plans until the matter of subways in the downtown streets had been decided.

In 1921 the matter of the inadequacy of the sewers in the loop was again brought to the fore, and plans were made for a system of relief sewers in the area. The estimated cost of these relief sewers was to be over a million dollars. These plans were never carried out, probably due to the opposition of property owners to paying the cost. It should be kept in mind that the cost of building sewers is met by spreading an assessment upon all the property affected.

All the foregoing indicates that for over 25 years those in authority have recognized the inadequacy of the sewers in the central business district of the city to handle satisfactorily the ordinary storm run-off of the district, and that those in authority have made plans to enlarge the sewers, but for one reason or another have been unable to carry out these plans.

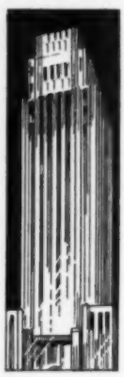
Now, with the rapidly increasing demand for water for cooling purposes in connection with the installation of air conditioning equipment, the inadequacy of these sewers is again brought to attention. During the past summer, on many clear hot days, the sewers have been flooded and have overflowed into the basements and subbasements of adjacent property. The matter has become acute, and some solution of the problem must be arrived at at an early date. The past summer has given such conclusive evidence that it can be stated without fear of contradiction that the present sewers in the loop area cannot dispose of the waste water from the central business district during the summer season at the present time, and will not be able to do so in the future unless something is done to reduce the amount of water used for air conditioning purposes.

Possible Solutions of the Problem

First, as recommended in the report of 1911, the entire sewer system in the loop area could be rebuilt at a cost of many million dollars, or, as recommended in

1921, a system of relief sewers could be constructed at a cost between one and two million dollars. The carrying out of either one of these programs would not only entail a very large expenditure, but it would cause a great deal of inconvenience in the streets of the loop carrying heavy traffic, and either program might meet opposition from the business interests in the area affected. It should be kept in mind that any rebuilding of the loop sewers is tied up with the plans for any future loop subways. Also remember that any expenditure made for enlarging the sewer system to carry away the waste water from air conditioning equipment would be made to meet a peak load demand occurring only during the summer months, or approximately 1,000 hours per year.

The second possible solution of the problem is for those requiring air conditioning equipment to so design and install that equipment that the amount of water required from the water supply system shall be reduced to a minimum. The installation of cooling towers, evaporative condensers or other devices that may be developed in the future would bring this about.



As far as the water supply system is concerned, we are in a position to deliver all the water that air conditioning may require, and we are glad to get the income from the sale of this water.

As to the cost of installing and operating cooling towers or other water conserving devices, an investigation carried out jointly by the bureau of engineering of the city and the Commonwealth Edison Co. indicates that the total cost of operation of a 300 ton plant in Chicago would be somewhat more with cooling towers than without.

On the other hand, the investigation indicates that the total cost of operation of a 900 ton plant would be somewhat less with cooling towers than without. The investigation also indicates that if the total amount of air conditioning equipment now installed in the loop area made use of water conserving devices, the total cost to the owners, including the cost of water power, maintenance and fixed charges, would not be much greater than it is at present without such devices.

In conclusion, may I say the problem of the bureau of engineering is to supply the demand for water, and we are in a position to meet the maximum demands of the loop area for at least the next ten years; the matter of disposing of the waste water from the loop area is a problem to be met by the bureau of sewers, and just how that part of the problem will be met, I am not in a position to state, but surely this problem of air conditioning is a major one and far reaching in its effects, and can only be solved by the combined planning and cooperation of all those concerned.

Table 1—Results of Tests on Three Installations Showing Air Conditioning Condensing Water Requirements

Installation No. 1.....440 tons, centrifugal refrigeration. The water going to this equipment is measured by a separate meter. A test was made on this equipment running from July 2 to July 30, 1936. During this period the equipment used an average of 371,000 gal of water per day.

Installation No. 2.....500 tons, steam jet refrigeration. The water to this equipment is measured by a separate meter. A test was made on this equipment from July 1 to July 30, 1936. During this period the equipment used an average of 972,000 gal of water per day.

Installation No. 3...350 tons, centrifugal refrigeration. Test made on this equipment from July 30 to August 24, 1936. During this period the equipment used an average of 316,000 gal of water per day.

The above three installations total 1,290 tons of refrigeration, and over the periods noted, used an average of 1,659,000 gal of water per day, or 1,286 gal per day per ton of refrigeration. If we assume that the equipment was operated an average of 10 hr per day, this gives a water demand of 2 gpm per ton of refrigeration.

Warns Against Cross Connections When Using Deep Well Water for Air Conditioning

In Winnipeg there is a growing tendency to use deep well water for commercial and industrial purposes and for air conditioning. Although the well water in this district is usually of a good quality, there is one case on record where a well became polluted and was abandoned, possibly due to defective well casing and infiltration of surface water. If one well can become dangerous, there is no telling when the others in use may become so also.

One example of a cross connection of this type came to my notice last November.

A recently built office building had a deep well bored to obtain cold water for air conditioning, supplying cold water at the drinking fountains and for flushing. The workman made a connection to the distribution pipe in the building so that the delivery from the well could be circulated to the air conditioning coils and drinking fountains. A pipe was extended from the coils and connected direct to the drain, suspended from the ceiling, to get rid of the water after passing through the coil. This combination had a cross connection between the city water supply, deep well water, and the plumbing and drainage system. A valve was placed on the line of piping between the city and the deep well system. Failure to close this valve would result in the well water being forced into the city water main owing to the high pressure maintained on the deep well pump.—J. McNeill.*

*Assistant Chief Plumbing Inspector, City of Winnipeg, Manitoba, Canada. Reproduced by permission from an article on cross connection problems in the Sept. 15, 1936, issue of the *Sanitary Engineer*.

Heat Losses Through Tiled Roofs

A report on heat losses through tiled roofs by H. E. Beckett, describing studies made at the Building Research Station in England, was published in the September, 1936, *Journal* of the *Institution of Heating and Ventilating Engineers*. The following conductances were recommended by the author for adoption for practical use:

Recommended Air-to-Air Conductances for Tiled Roofs (Btu per Sq Ft per Hr per F)

Boarded and felted	0.35
On battens only	1.50
On battens, torched	0.95

Other types of tiled roofs are to be tested during the coming winter, but the boarded and felted roof will be retained as a standard of reference throughout the experiments.

Multi-Layer Oxy-Acetylene Pipe Welding

[Part 1]

By R. M. Rooke* and F. C. Saacke*

THE deposition of weld metal in more than one layer is not a new process. The advantages are patent. The ductility of cast steels may be increased by the grain refinement obtained by reheating and cooling the steels through the critical temperature ranges.

Multi-layer welding has been recommended and used in the past in oxy-acetylene welding but not in the most desirable form. It was readily recognized that with parent metal thicknesses over ¾ in. or even ½ in. that the weld of necessity must be made in more than one layer; but it was not realized how important the length of the layers is in securing the ultimate in physical characteristics of the weld metal. Thus, previous multi-layer welding was practiced with the layers alternating in short steps of approximately 1 in. in length which did not allow the lower layers sufficient time to cool below the critical temperature of the steel before covering with further layers of weld metal. Consequently, these short-step multi-layer welds did not develop very great ductility; the weld metal lacked that heat treatment available in long-step multi-layer welding.

It was probably the necessity for preheating that caused the assumption in oxy-acetylene welding that to bring any part to be joined up to a welding temperature more than once during the welding process would be slow and an uneconomical operation. Nevertheless, experiments carried out on 8 in. diameter Grade *A*[1] (48,000 psi minimum tensile) and Grade *B* (62,000 psi minimum tensile) pipe with wall thicknesses of ½ in. and over have shown, when single- and multi-layer gas welds are made under the same conditions and on the same wall thicknesses, that the physical characteristics, particularly the ductility of the multi-layer welds, are not only superior but the welding times as well as the filler rod and gas consumptions are considerably lower.

The superiority of the physical characteristics of the multi-layer welds depends upon two factors. (1) The weld metal is deposited in better condition due to the reduction in size of the molten puddle. With the increased linear speed of welding, the molten metal is less turbulent and worked at a lower temperature; it is exposed to the atmosphere for a shorter period of time and is more completely protected by the envelope of welding gases, and it is more readily bonded to the parent metal free from cold shuts or slag inclusions due to the simplification of the welding. (2) The weld metal ductility is improved markedly with very little sacrifice of tensile strength by the grain refinement resulting from the welding heat of successive layers of weld metal. This latter grain refinement, it must be remembered, is only present if the layers of weld metal are deposited in such lengths that the weld metal is reheated through the critical temperature range.

Comparison of Weld Metal Cross Sections

Fig. 1 shows five typical weld cross-sections. On $\frac{5}{16}$ in. steel parent metal, we have a typical cross-section of a single-layer backhand weld. The penetration is held to a minimum while the width of the weld only slightly exceeds the maximum width of the 60 deg vee.

On ½ in. steel parent metal, the left-hand figure shows a typical weld with the bad features resulting from the difficulties encountered in controlling such a large puddle of weld metal. In the effort to secure proper penetration at the bottom of the vee, the side walls are melted excessively and to correct the tendency of the weld from being undercut at the surface, the weld has to be widened excessively which in turn increases the height unnecessarily.

The ½ in. multi-layer weld on the other hand has avoided these difficulties by cutting down the cross-section of the weld to the point where it can be properly controlled without difficulty and at the same time dividing up the details of welding so that the operator concentrates on the root of the vee in the first layer and on the surface of the weld and the proper penetration while depositing the second layer.

On ¾ in. steel parent metal, the faults of the single-layer weld are still further apparent as the welding rod

*Apparatus Research and Development Dept., Air Reduction Sales Co., New York, N. Y.

From a paper presented at the annual meeting of the *American Welding Society*, Cleveland, Ohio, October, 1936. Complete paper published in the October, 1936, issue of the *Journal* of the *A. W. S.*

[1] *A. S. T. M.* Specification A 106-34T.

According to the authors of this paper—which was presented at the *American Welding Society's* annual meeting last month—the advantage of the deposition of weld metal in more than one layer is that the ductility of cast steels may be increased by the grain refinement obtained by reheating and cooling through the critical temperature ranges. . . . They draw the following conclusions: (1) multi-layer welding improves the ductility and impact value of the weld metal with little sacrifice in tensile strength so that with suitable welding rods, free bend ductilities of 50 per cent, Charpy impact values of 30, with tensile strengths in excess of that of the pipe, may be obtained; (2) the welding operation on thick wall pipe—½ in. wall thickness and over—is simplified by the reduction in size of the molten puddle of weld metal; and (3) gas consumption and welding time are appreciably lowered with multi-layer welding

and torch motions become greater and greater. The left-hand figure shows a typical cross-section of such a weld made by an expert operator. The average good operator will invariably do a poor job if he attempts to make the weld in a single layer. And after all, why should he be expected to make a good job with such a method? On $\frac{5}{16}$ in. walls, he uses a $\frac{5}{16}$ in. diameter welding rod. How can he handle a ¼ in. rod on ¾ in. parent metal thicknesses without more than doubling the diameter of the welding orifice? The welding rod is too big for a smaller gas flow. With a larger gas flow, the operator gets too hot and if he trys to stand farther away the rod and torch become unwieldy.

The right-hand weld on the ¾-in. parent metal shows how the smaller cross-sections of the weld layers simplify and still further subdivide these problems.

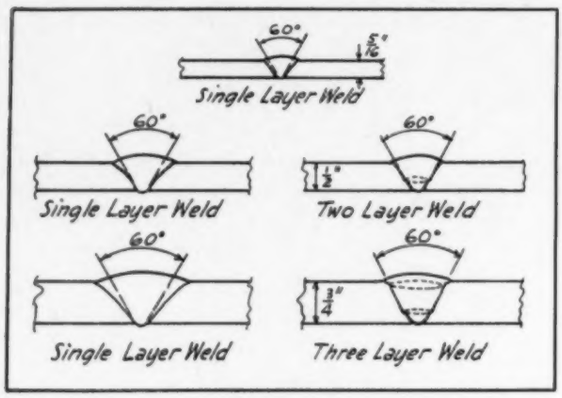


Fig. 1 — Individual cross sections of one-, two-, and three-layer welds

Fig. 2 shows how the multi-layer welds compare in outline with the single-layer welds and how much of the steel parent metal is unnecessarily melted in making the single-layer welds.

Three Layer Rolling Pipe Weld

Let us first consider a three layer rolling weld on ¾ in. wall pipe, 8 in. nominal diameter, as that problem embodies all the features of this multi-layer welding method whether applied in two layers on ½ in. wall thicknesses or in four layers on 1 in. walls or more in the case of heavier sections.

The multi-layer weld is not limited to a rolling weld; it may be applied to a position weld equally as well. A single-layer position weld of extra heavy pipe is the most difficult to make satisfactorily and the application of multi-layer welding to a position weld of this size is particularly desirable.

The pipe is beveled at a 30 or 37 deg angle and tack welded in three or more places. The first layer of weld metal (Fig. 3, 1*A*) is started midway between two of the tacks on the side of the pipe facing the operator about 15 to 45 deg from the vertical. It is deposited by the backhand method of welding, as are all the succeeding layers, until the operator cannot comfortably reach much further over the pipe. This segment of the first layer, therefore, ends on the other side of the pipe about 15 to 45 deg from the vertical. During this step, the pipe which may be in long or short lengths has remained stationary.

The operator then goes back to the beginning of this step which has now cooled below the critical temperature of the weld metal and starts the first segment of the second layer (Fig. 3, 2*A*). In doing this, he is careful to slope the start of the first layer with the torch and start the second layer a trifle past this point. The end of any complete pass of weld metal around the pipe should be completed against a slope instead of an abrupt change in section.

The pipe is now turned during this second layer maintaining the molten puddle in the same position on the near side of the pipe until the end of the first layer is reached. Then, without removing the welding rod or in any way interrupting the operation, the weld slopes down to the level of the first layer and the second step of the first layer (Fig. 3, 1*B*) is finished with the pipe stationary similar to the first step. The first two layers are thus deposited alternately in steps ranging from 2 to 6 in. or more until the pipe has been completely turned through one revolution.

These two layers deposited alternately in 2 to 6 in. steps in one complete pass around the pipe would be sufficient for a weld on pipe of ½ in. wall thickness as indicated in Fig. 1. On the ¾ or ⅞ in. wall pipe, another layer is required and this is made continuously in a single pass around the pipe (Fig. 3, 3). The end of the second layer and the start of this third layer are identical as the welding is continuous. In view of the fact that the outer layer of weld metal is often allowed to remain with its cast structure unchanged by any further heat treatment, this outer layer is usually kept as thin as practicable.

If we now analyze the difference in conditions as we make this multi-layer weld and compare them with the conditions existing while making a single-layer weld, we can more easily understand the improved efficiencies. There are three main reasons why the single-layer welds on heavy wall pipe are less efficient:

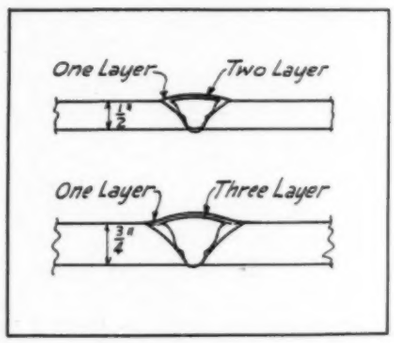


Fig. 2—Superimposed cross-sections of two- and three-layer welds

First, in a single-layer weld a great deal of the hot gases from the oxy-acetylene welding flame never touch the weld but pass through the opening at the bottom of the vee and are almost useless so far as utilization of their thermal energy is concerned. In a multi-layer weld, this situation occurs only with the first layer and then at a smaller gas flow and a much more rapid linear speed of welding.

Second, the cross-section of the single-layer weld is much larger than the multi-layer weld which is again an indication of the excessive consumption of thermal energy in penetrating the side walls of the pipe deeper than necessary.

Finally, the single-layer weld being more difficult to make on the heavier parent metal sections becomes excessively slow due solely to the difficulties of the welding operation.

If we consider each of the three layers of weld metal

separately, the necessity for multi-layer welding becomes more evident.

The first layer is deposited initially for two reasons, either of which is sufficient to justify its use. It should be remembered that the welding of a beveled edge is a complex problem in many ways. The rate of heat transfer naturally varies from a minimum at the tapered edge of the beveled plate to a maximum at the upper edge. The problem becomes, in a single-layer weld, one of so distributing the heat from the welding torch and controlling the rate of cooling that the molten puddle is kept uniformly liquid (at a uniform temperature). With relatively thin parent metals, this is simple enough. With thicker sections it becomes difficult and the bottom of the vee either overheats and lets the metal run through or it is kept at too low a temperature and the molten metal runs over a thin film of liquid slag leaving slag inclusions and cold shuts.

Thus, one important consideration is the necessity of sealing the bottom of the vee free from cold shuts, slag inclusions and icicles. Furthermore, under the varying stresses and strains while welding, the spacing of the root of the vee sometimes varies and it becomes quite difficult to seal this properly when excessively wide when carrying a large puddle of weld metal. The other reason for this first layer, of course, is to seal the opening at the root of the vee so that the thermal energy of the welding gases is utilized more economically in depositing further layers of weld metal.

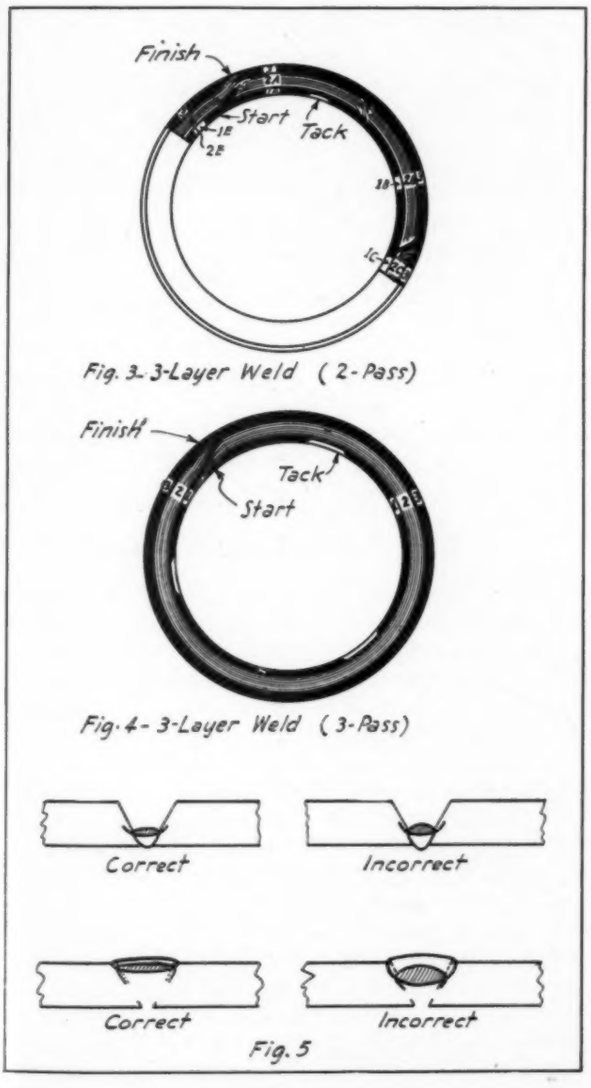
The second layer is deposited with one sole object and that is to fill in the vee with weld metal properly fused into the walls of the parent metal without undue overheating or turbulence, all of which may leave oxide inclusions and blow-holes that lower the physical characteristics of the weld metal. On ¾ or ⅞ in. walls, a single fill-in layer is often sufficient; on 1 in. walls, it is recommended to use two fill-in layers, and so on, depending upon the thickness of the parent metal since the maximum cross-section of the weld metal layers is limited by the ability of the operator to deposit the metal quietly without undue turbulence.

The last layer is then simply a problem of completing the weld and concentrating on keeping the weld as narrow and with as little reinforcement as possible as the upper edges of the vee have not yet been touched and readily outline the desired width of the weld. In this layer, it is a simple matter to prevent undercutting and keep a suitable reinforcement.

Fig. 3—Three-layer two-pass pipe weld cross-section

Fig. 4—Three-layer three-pass pipe weld cross-section

Fig. 5—Correct and incorrect shapes of surfaces of first and second layers of three-layer weld



Shape of Layers

The first problem arises from the natural tendency of each layer to be convex on top with sharp vees of unbonded metal on each side. This must be avoided as each succeeding layer must be sunk into the preceding layer until the bottom of the lowest unwelded spot is reached. If each layer is deposited with a flat or concave upper surface, no remelting of the lower layer is necessary beyond that required to suitably bond the two layers together. Consequently, each layer except the final one is deposited with the upper surface either flat or concave or with as little convexity as practicable. This is not always possible in the first layer due to the speed of deposition, the temperature of the side walls and the nature of the welding operation. The convexity that is obtained in the first layer, unless excessively high, is not so important, as the cross-section of the first layer is so small that even if the first layer is half remelted to reach below all unwelded points, the total volume of metal remelted is still small. The nature of the upper surfaces of the weld metal layers is not evident in Fig. 1 but has been outlined in Fig. 5 to show the natural tendencies as well as the most desired shapes.

The second problem arises from the necessity for maintaining the maximum efficiency in such an operation. The first two layers can be deposited either in two complete separate passes (Fig. 4), that is, completing the entire first layer all the way around the pipe before starting the second layer, or alternating the two in steps of a nominal size, but completing the two layers in one complete pass around the pipe.

One advantage of making the first two layers alternately in definite steps is to reduce the amount of pipe turning necessary when making a rolling weld. Thus, the first two layers of a rolling weld if made in two passes

require the pipe to be turned completely through two revolutions and when handling long pipe lengths is obviously not as satisfactory as if turned only once as is the case when making the first two layers in one pass by alternating the two as shown in Fig. 3.

The primary reason, however, for alternating the first two layers is the improvement in the welding efficiency. It takes less heat or thermal energy to join the lower edges of the bevel than to fill in the vee. Consequently, when one step of the second layer comes to the end of the lower step of the first layer and the weld drops down to continue another step of the first layer, there is more heat in the pipe at this point than is needed to maintain the deposition of the first layer at a constant speed. In other words, the preheat available for the second and all succeeding steps of the first layer is greater than was used to start the first step of the first layer. The deposition of these subsequent steps of the first layer, therefore, progresses at a much higher initial rate than the first step of the first layer, diminishing of course as the first layer progresses away from the last step of the second layer until a point is reached where the welding speed has reached an equilibrium or constant speed of the same magnitude as the speed of deposition of the first step of the first layer.

The actual length of these steps is a little short of this equilibrium point and is determined by the comfort with which the operator can make a first class deposit without changing his position or rolling the pipe. Thus, all steps but the first step of the first layer are deposited under conditions that make available the welding heat of the second layer which means that the first layer is deposited at a higher over-all speed than would be the case if it were made in a continuous pass before starting the second layer without using a higher gas flow.

Welding Technique

The maximum efficiency obtainable is also dependent upon the variables present in all oxy-acetylene welding operations, notably the welding flame, welding rod size and the position of the torch and welding rod.

The welding flame should be soft and of the bulbous type, and adjusted to insure a neutral welding atmosphere. The welding rod is preferably of ¼ in. size for the first layer and $\frac{5}{16}$ in. size for subsequent layers.

It is not necessary to use two sizes of welding rods, but it speeds up the operation. The use of a $\frac{3}{16}$ or ¼ in. rod for the first layer is governed by the spacing at the root of the vee and the desired size of the first layer. The fill-in layers are made larger with the torch flame playing directly on the end of the welding rod and melting it down as rapidly as possible. Consequently, a larger rod or even two ¼ in. rods may be used to make the welding progress faster.

The proper relative positions of the torch and welding rod will vary during the welding. During the entire weld, the welding rod is held between the torch and the molten puddle of weld metal. In the first layer, the welding flame is pointed back toward the molten puddle while in the remaining layers the welding flame is held almost vertical (radial). Between these two positions, the angle of the welding flame will vary according to the condition of the molten puddle and the control necessary.

An operator after a little practice should have little difficulty in securing strong, ductile welds on thick walled pipe by using the multi-layer method of welding. The higher welding speeds and economy of operation will depend upon the ability of the operator and will improve along with his experience in making multi-layer welds.

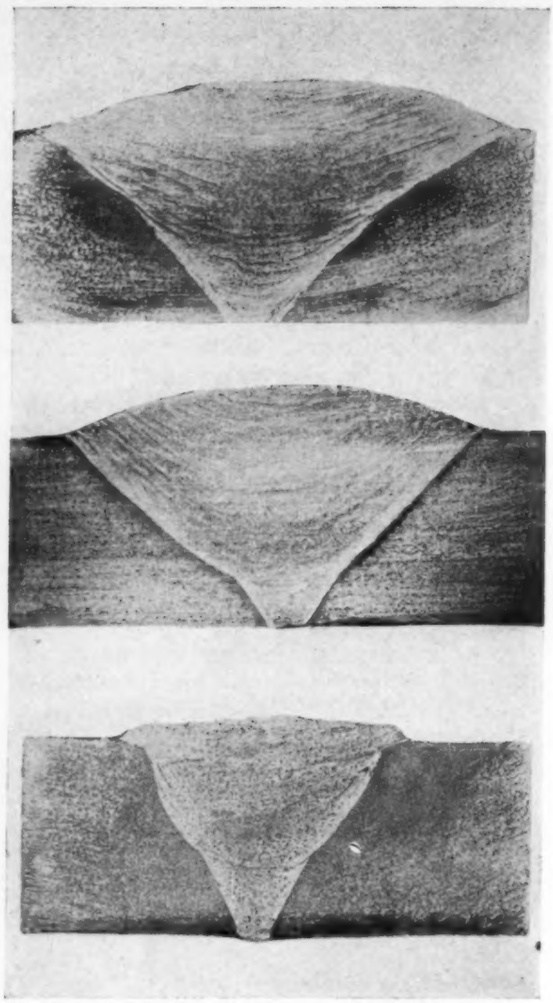


Fig. 6—(Top to bottom)—One-, two-, and three-layer cross-sections

Tests of Multi-Layer Welds

Physical tests of multi-layer welds have shown varying but definite increases in ductility and impact strength depending upon the welding rod used.

Using a 3½ per cent nickel steel with a carbon content of approximately 0.20 per cent for a filler material, an increase in ductility as measured by the free-bend test of from 10 per cent in a single-layer weld on ¾ in. wall, Grade *B* pipe, to over 50 per cent without failure in a three-layer weld on the same pipe was obtained. With a lower carbon content of approximately 0.10 per cent an increase in ductility of from 20 per cent in a single-layer weld to over 45 per cent in a three-layer weld was obtained. Other welding rods have shown similar increases in ductility by multi-layer welding although not to such a great extent as the nickel alloy steels.

Even low nickel-steel welding rod designed to give high ductilities with single-layer deposits of weld metal

Table 1—Performance of Single- and Multi-Layer Welds on 8 In. Pipe

Wall Thickness (In.)	7/16	7/16	3/4	1/2	1/2	1/2	5/16
Type Weld (No. of* Layers)	3	2	3	3	2	1	1
Time (Min.)	63	123	60	54	37	69	14.5
Rod Consumption (Lb)	6.1	5.8	4.9	2.1	1.9	2.2	0.9
Gas Consumption (Cu Ft Acet.)	101	152	97	34	34	45	7.8

* Unless otherwise noted, the number of passes is always one less than the number of layers in a multi-layer weld as the first two layers are deposited alternately in one pass.

showed improved ductilities. Tests showed the weld metal ductility with this rod drops from 33 to 20 per cent as the wall thickness of the pipe being welded in a single-layer deposit increases from 5/16 to 7/8 in. When multi-layer welding is substituted for single-layer welding, the welding is not only speeded up and simplified at the same time, but the ductilities are brought up to 35 per cent on the 7/8 in. wall.

The tensile strengths of all multi-layer weld specimens showed an apparent average drop of about 5 per cent but this is negligible as all the welds were considerably stronger than the pipe. All unreinforced full section tensile test specimens failed in the parent metal whether using single or multi-layer welds.

Charpy impact tests of single- and multi-layer welds using the low nickel-steel welding rod on 8 in. Grade *A* seamless pipe of 7/8 in. wall thickness showed the following: There is an increase in the impact value as the number of weld metal layers on the pipe of 7/8 in. wall thickness is increased. Single-layer welds show impact values of 34.5 per cent of the pipe. Multi-layer welding raises the weld metal impact value up to 48.4 per cent of the pipe in a two-layer weld and up to 66.8 per cent in a three-layer weld. The impact value of the two-layer weld represents a 40.1 per cent increase over that of the single-layer weld while the three-layer weld shows an 84.7 per cent increase. This 84.7 per cent increase in impact value as a result of multi-layer welding compares very well with the increase of 75 per cent in ductility indicated for the low nickel on 7/8 in. wall pipe.

Like single-layer welds, the physical properties of multi-layer welds as well as the welding efficiencies will depend upon the composition of the welding rod and parent metal, the type and size of welding flame, the amount of reworking of the weld metal, the depth of penetration of the weld into the side walls of the pipe and the relative sizes and number of the layers. Consequently, no effort has been made to tabulate the results obtained from the use of various welding rods other than to show for any given set of conditions how the welding speeds, gas consumptions and weld metal physical characteristics are improved by multi-layer welding.

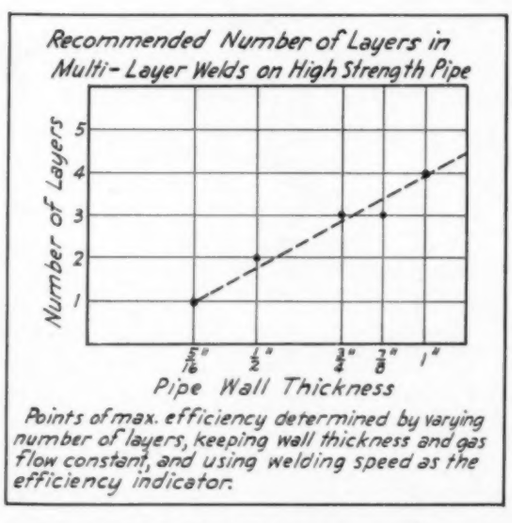


Fig. 7—Graph of pipe wall thickness vs. number of layers

Most Efficient Welds

In Table 1 are listed the most efficient welds of the various types made on 8 in. pipe ranging in wall thickness from 5/16 to 7/8 in. On the 7/8 in. walls, the three-layer weld lowered the welding time of a two-layer weld by almost 50 per cent and was by far the more efficient. On the 1/2 in. walls, the two-layer weld was the fastest and most efficient with the three-layer weld next and the single-layer weld last. A visual inspection of the 5/16 in. wall thickness pipe weld was sufficient to eliminate the use of multi-layer welding on this relatively thin wall pipe.

The most efficient welds (in *italics*) in this table were then used in Fig. 7 to show the approximate relation between the wall thickness and the number of layers for pipe welds.

Other experiments may still prove further the value of multi-layer welding to secure the ultimate in physical characteristics.

[Part 2, by Arthur N. Kugler—to appear later—discusses power piping applications.—Ed.]

Air Conditioned Test Rooms Improve Product

Air conditioned testing departments for insuring greater accuracy of the work and more comfortable working conditions for the operators are being used at Westinghouse's East Springfield, Mass., appliance manufacturing plant with excellent results.

Soundproof and practically air tight test booths, requiring ventilation, have been in use for some time. Previously the ventilation of these booths was taken care of by the addition and proper circulation of outside air, no means being provided for removal of internal heat created by the appliances and the operators; consequently the temperature rose to an uncomfortable degree.

At the present time, operators are working under ideal air conditions in these booths. Temperature is controlled and maintained at a comfortable point regardless of outside conditions, and with no sacrifice of soundproofness. This has been accomplished by means of a central conditioner and a distributing duct system which takes care of several booths. The duct is lined with a sound absorbing material and is connected to the booths by canvas connectors, which features reduce to a minimum noise transmission from the fan and other sources to the inside of the booth. The system is designed so that all of the air may be recirculated or else partly recirculated and make-up air added in any desired proportions.

Since the installations have been made, it has been found that the operators are more alert and better fitted to conduct the tests competently and thoroughly.

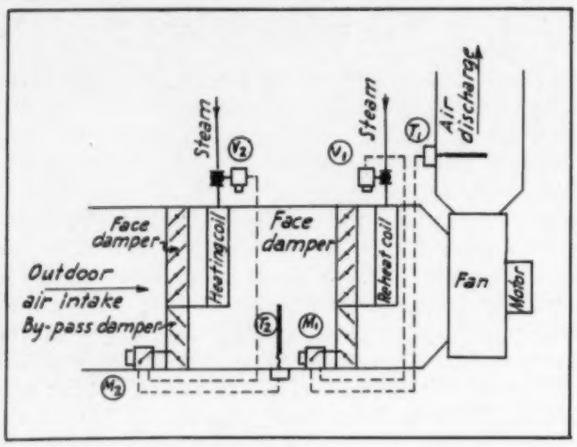
CONTROLS

By C. L. Ringquist*
Reference Sheet 3

Although data on automatic controls for heating, humidifying, dehumidifying, ventilating, cooling and complete air conditioning may be had from numerous sources, information on groups of controls applicable to various types of systems is not so readily available. The author has therefore diagrammed typical control layouts, with each of which is given an explanation of the control cycle. . . . For the purpose of illustration, central fan coil types of systems are used; the control arrangements described are equally applicable to units built up to perform the same functions. . . . Types of systems covered by this series include humidifying; ventilating; heating and ventilating; heating, ventilating and humidifying; cooling, dehumidifying and ventilating; cooling, dehumidifying, ventilating and humidifying; heating, ventilating, dehumidifying and cooling; heating, ventilating, dehumidifying, cooling and humidifying; and zone control systems.

VENTILATING [Continued]

System for Ventilation Purposes Only, with Preheating Coil and Control for Accurate Control and Economical Operation:



Symbols

M_1	Damper motor
M_2	Damper motor
T_1	Duct thermostat
T_2	Duct thermostat
V_1	Modulating valve
V_2	Modulating valve

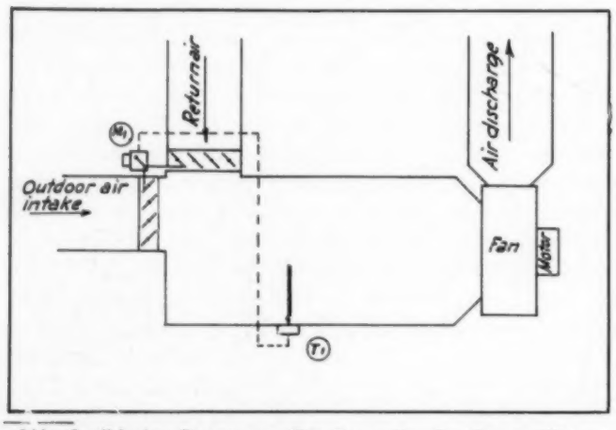
Cycle—T_2 controls amount of air drawn through face damper and coils or through bypass by means of M_2. As more heat is required to bring up the leaving temperature, face damper opens wider and bypass damper closes more and *vice versa*. M_2 is equipped with an auxiliary contact connected to V_2. V_2 modulates at all times except when the face damper is entirely closed, at which time the auxiliary contact on M_2 acts to close the valve tight.

T_1 controls action of face and bypass dampers through M_1, which is equipped with an auxiliary contact to close V_1 whenever the face damper is entirely closed.

The object of using face and bypass dampers is to insure a heating coil which is entirely filled with steam to prevent chances of freeze-up should the valve throttle in extremely cold weather, as may be the case when using a modulating valve only.

The auxiliary contact used on the damper motors for closing V_1 and V_2 acts to give more even control in mild weather and conserves steam when the air does not require heat. It also acts to prevent what is commonly known as "drift" when the face damper is closed. "Drift" refers to the fact that a certain amount of heat may be picked up by the movement of the air through the bypass damper (when not required) if the steam supply to the coil is not shut off with closing of the face damper.

Simple Ventilating System; No Heat Available for the Ventilating System. (Should not be used in extremely cold climates without the use of booster heaters to prevent drafts and discomfort from low outlet air temperatures):



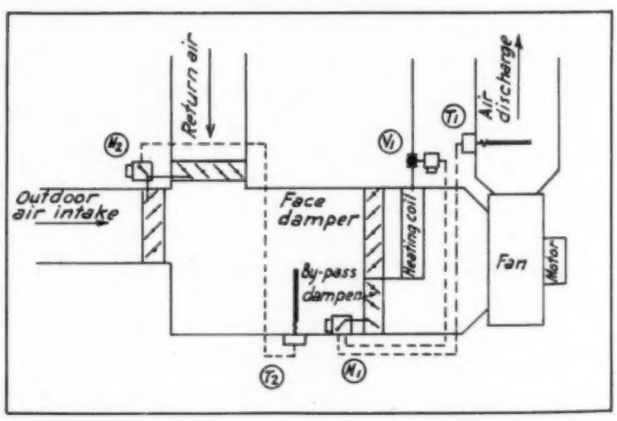
Symbols

M_1	Damper motor
T_1	Duct thermostat

Cycle—T_1 controls temperature of the air mixture by adjusting the amount of return air and outside air drawn into the system by means of the two dampers and M_1. As the temperature rises above the setting of T_1, the outside air damper opens wider and the recirculated air damper closes more.

Outside air damper has a fixed minimum point so that at all times outside air of at least a predetermined amount is drawn into the system.

Same as Preceding Example, with a Heating Coil and a Set of Face and Bypass Dampers, together with the Controls, Added:



Symbols

M_1	Damper motor
M_2	Damper motor
T_1	Duct thermostat
T_2	Duct thermostat
V_1	Modulating valve

Cycle—Same as preceding example. After the two volumes of air have been mixed, mixture is drawn either through the face damper and heating coil or part bypassed as required by the setting on T_1.

Additional controls required over preceding example are:—T_1 set to control discharge air at a constant temperature by adjusting the face and bypass dampers to pass more or less air through the heating coil. The face and bypass dampers are controlled by M_1, which is equipped with an auxiliary switch to modulate V_1.

This system has the advantage of supplying as much outdoor air as possible without increase in steam consumption.

*Air Conditioning Department, The Trane Co., La Crosse, Wis.

Heating·Piping
and Air Conditioning

American Society of Heating and Ventilating Engineers JOURNAL SECTION

NOVEMBER 1936

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Thermal Properties of Concrete Construction

(Part 2)

By F. B. Rowley,* A. B. Algren,** (*MEMBERS*) and Robert Lander† (*NON-MEMBER*)
Minneapolis, Minn.

This paper is the result of research sponsored by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS *in cooperation with the Portland Cement Association and the University of Minnesota.*

THE thermal properties of concrete construction have been under investigation for the past two years as a cooperative research program between the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, the *Portland Cement Association,* and the University of Minnesota. The results of the first part of the work were reported in a paper entitled, Thermal Properties of Concrete Construction, in the A. S. H. V. E. JOURNAL SECTION, *Heating, Piping and Air Conditioning,* January, 1936.

Since that time the work has been extended to include more masonry walls, insulated monolithic walls, and the thermal conductivity of different aggregates. This paper covers the work completed since the previous report together with a summary and conclusions for the project as a whole.

In order to facilitate comparisons between the results reported in the two papers, the data are presented in the same form for both papers. In so far as possible the numbers and headlines designating the various tables are identical, and Tables 1, 2, 3, 4, 5 and 6 in this paper may be considered as a continuation of tables of like numbers in the previous paper.

As stated in the previous report, there are several possibilities of improving the thermal properties of concrete construction, among which are the selection of a low conductivity aggregate, the construction of a wall with suitable air spaces, the application of surface finish, and the use of specific insulating materials. The first part of the investigation covered only a limited number of aggregates and did not include any monolithic walls poured with insulation between the slabs. The present report covers a more thorough investigation of different aggregates, both by the hot plate and hot box test methods, additional work on the insulating value of air spaces, and a rather extensive investigation to determine the value of different types of insulating materials when built as integral parts of monolithic concrete walls.

Method of Procedure

The aggregates used in the construction of the various walls were selected and graded as per specifications. A sieve analysis was made and the different aggregates for a given wall were mixed in the required proportion to give the proper fineness modulus. Preliminary tests were made to determine the proper water to cement ratio to give the required slump and strength characteristics. All blocks for masonry walls with the exception of Walls 9a and 12a were made in a standard block machine at the Crown Sidewalk and Block Co.'s plant, Minneapolis, Minn. They were steam cured for 24 hours and then exposed to air for the remainder of the curing period. After the blocks were thoroughly dried they were built into test walls 5½ ft square using ⅜ in. mortar joints between the blocks. The mortar was buttered on the edges but not on the cross partition between the air cells, thus following recommended and standard construction practice for walls of this type. After allowing a sufficient time for the mortar joints to thoroughly dry the walls were tested by the standard hot box method.

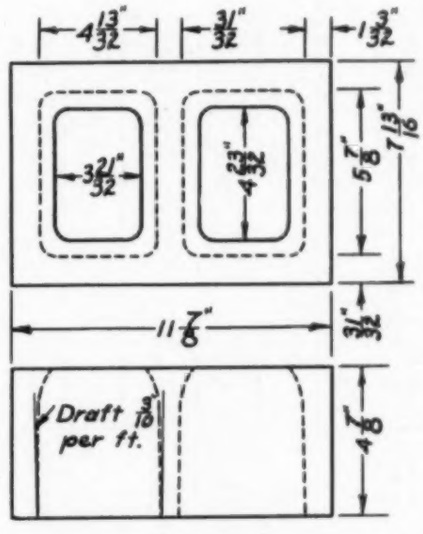

Fig. 1—2 core block 5 in. x 8 in. x 12 in. Used in walls 9a and 9b

For the monolithic walls the aggregates were selected and graded in the same manner as for masonry construction and the walls were built in the laboratory according to specifications. At the time of pouring the walls, 6 in. x 12 in. cylinders were cast which were later tested to give the

*Director of Experimental Engineering Laboratories, University of Minnesota.
**Assistant Professor of Mechanical Engineering, University of Minnesota.
†Research Engr., University of Minnesota.
For presentation at the 43rd Annual Meeting of the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS, St. Louis, Mo., January, 1937.

Table 1—Masonry Walls—Description and Data

Wall No.	Type of Aggregate	Description of Blocks	Density of Material in Blocks Lb/Cu Ft	Per-centage of Core Volume	Over-all Thickness of Wall in Inches	Inside Surface Finish	Outside Surface Finish	Additional Insulation in Wall	Density of Insulating Material Lb/Cu Ft	Weight of Insulating Material per Sq Ft of Wall Area Exclusive of Surface Finish	Aggregate Used in Wall Per Cent by Weight	Fineness Modulus of Aggregate			Dry Rodded Weight of Aggregate Lb/Cu Ft		Mix Proportion Rodded Dry Vol.	Water Cement Ratio W/C Gal/Sack	28 Day Compressive Strength Air Dried				Per Cent Absorption at 28 Days	
												Fine	Coarse	Combined	Fine	Coarse			Area of Specimen Sq In.		Total Breaking Load Lb	Breaking Load Lb/Sq In.		
																			Gro.	Net		Gro.	Net	By Wt.	By Vol.
9a	Sand and Gravel	5"x8"x12" 2-Core Tile	133.9	49.3	7.78	As Laid	As Laid	None	—	—	72.3 Per Cent Sand 27.7PerCentGravel ¾ in. to 0	3.15	5.74	3.88	113	105	1:7	7.5	91.2	46.3	11,800	1295	2550	5.7	12.2
9b	Sand and Gravel	5"x8"x12" 2-Core Tile	133.9	49.3	7.78	As Laid	2 Coats Water Proof White Cement Paint	None	—	—	72.3 Per Cent Sand 27.7PerCentGravel ¾ in. to 0	3.15	5.74	3.88	113	105	1:7	7.5	91.2	46.3	11,800	1295	2550	5.7	12.2
11a	Air-Cooled Slag	8"x8"x16" 3-Oval Core	126.3	42.4	7.85	As Laid	As Laid	None	—	—	100 Per Cent Slag ½in.-0,56.5 PerCent Fine, 43.5 Per Cent Coarse	2.29	5.92	3.92	105	79	1:8	7.3	124.1	71.5	113,400	914	1588	8.8	17.9
12a	Sand and Gravel	5"x8"x12" Blystone Tile	133.7	45.3	7.78	As Laid	As Laid	None	—	—	72.3 Per Cent Sand 27.7PerCentGravel ⅜ in.-0	3.15	5.74	3.88	113	105	1:7	7.5	91.5	50.0	124,000	1367	2500	5.7	12.2
13a	Haydite	8"x8"x16" 3-Oval Core	67.7	39.6	9.69	As Laid	Furred with Cinder Tile Fig. 5	None	—	—	100PerCent Haydite 64 Per Cent Fine 36 Per Cent Coarse	2.76	5.94	3.92	58	43	1:8.5	10.82	125.5	75.75	97,780	770	1280	24.4	25.5
14a	Haydite	8"x8"x16" 3-Oval Core	67.7	39.6	9.69	As Laid	Furred with Haydite Tile Fig. 5	None	—	—	100PerCent Haydite 64 Per Cent Fine 36 Per Cent Coarse	2.76	5.94	3.92	58	43	1:8.5	10.82	125.5	75.75	97,780	770	1280	24.4	25.5
2c	Haydite	8"x8"x16" 3-Oval Core	67.7	39.6	7.91	As Laid	2 Coats White Water Proof Cement Paint	Cores filled with Granulated Cork	5.06	1.33	100 PerCentHaydite 64 Per Cent Fine 36 Per Cent Coarse	2.76	5.94	3.92	58	43	1:8.5	10.82	125.5	75.75	97,780	770	1280	24.4	25.5
3c	Sand and Gravel	8"x8"x16" 3-Oval Core	126.4	39.8	7.88	As Laid		Cores filled with Granulated Cork	5.14	1.35	73 Per Cent Sand 27 Per Cent Pea Gravel	3.22	5.68	3.91	108	105	1:10	8.92	124.9	75.18	137,440	1100	1829	8.3	16.7
5b	Cinder	8"x12"x16" 3-Oval Core	86.2	40.2	11.68	As Laid	As Laid	Cores filled with Granulated Cork	5.24	2.10	100 PerCent Cinders ½ in.-0	4.05	—	4.05	63	—	1:8	12.30	188.5	112.8	154,857	820	1369	14.4	19.9
15a	Haydite	8"x12"x16"	76.7	43.1	11.75	As Laid	As Laid	None	—	—	100 PerCentHaydite 64 Per Cent Fine 36 Per Cent Coarse	2.76	5.94	3.92	58	43	1:8.5	7.8	185.9	105.9	136,750	736	1294	16.0	19.6
15b	Haydite	8"x12"x16" 3-Oval Core	76.7	43.1	11.75	As Laid	As Laid	Cores filled with Granulated Cork	5.60	2.38	100 PerCentHaydite 64 Per Cent Fine 36 Per Cent Coarse	2.76	5.94	3.92	58	43	1:8.5	7.8	185.9	105.9	136,750	736	1294	16.0	19.6

strength of the concrete. After the walls were thoroughly dried and cured they were tested in the same manner as the masonry walls.

The group of monolithic walls, Nos. 38a to 43a, inclusive, were poured with a sheet of insulating material in the central plane of the wall. For these walls the forms were assembled, a sheet of the required insulating material set in position with reinforcing bars on each side and the aggregate poured and rodded in place. Samples of the insulating materials used in the different walls were selected during the construction of the walls and later tested by the hot plate method to determine their thermal conductivity. The conductivity values for the insulating materials were corrected for the effect of tie rods and these corrected values, together with selected conductivity values for the aggregates, were used to calculate the over-all coefficient of heat transmission for the walls. These values were then compared with the test results.

The thermal conductivities of additional aggregates were determined by building up test samples 24 in. square by 2 in. thick and testing them by the standard hot plate method. These samples were built by the *Portland Cement Association* according to specifications as given in Table 8. Even though these samples were cast between plates with relatively smooth surfaces, it was practically impossible to get a good contact between the surface of the test plate and the specimen. In order to overcome this difficulty sheets of sponge rubber 3/16 in. thick were cemented to both the hot and cold surfaces of the copper test plates. Four thermocouples, each slightly flat, were placed on each rubber surface and held in place by small pieces of adhesive tape at least 2 in. from the thermocouples. The test plates were clamped sufficiently tight to insure good contact between the plate and the test specimen through the rubber pad. Thirty-six thickness readings were taken in

the test area for each specimen and used to compute the conductivities. Sixty-four thickness readings covering the entire area of sample were used to compute the density of the specimens. This procedure proved satisfactory and duplicate tests checked within about 2 per cent.

The water absorption was determined by immersing the sample vertically in water for 24 hours, then removing and wiping off the surface moisture with a damp cloth and weighing.

The approximate percentage of voids for all but the most porous specimens, 1D to 5D, was obtained by placing the samples vertically in water for 24 hours and then removing and weighing immediately without wiping off the surface water. The gain in weight over the oven dry weight of the sample together with the volume of the sample was used to calculate the percentage of voids. The dry weight of the sample used for calculating the water absorption and approximate percentage of voids was obtained by drying the samples to a constant weight in a steam heated oven at a temperature of approximately 150 F. The approximate percentage of voids for samples 1D to 5D, inclusive, was obtained by a displacement method. In this method a tank 3 in. x 26 in. in area and 33 in. deep was equipped with an inclined gage for accurately determining its water level. The tank was then filled with water to a certain level and an amount of water equal to the volume of the specimen was removed. The specimen was immersed in the tank and allowed to stand for 24 hours with the tank covered to reduce evaporation. After the 24-hour period the surface bubbles were removed from the side of the specimen and enough water was added to bring the water in the tank back to the original level. The volume of the water added, divided by the volume of the specimen was used as the approximate percentage of voids. This procedure eliminated the possibility of removing too much water from the surface of the specimen by the standard method.

Description of Materials Tested

The complete physical data for the walls tested are shown in Tables 1 and 2 for masonry and monolithic walls, and the construction data are shown in Tables 3 and 4 for masonry and monolithic walls, respectively. Figs. 1 to 4, inclusive, shows the detailed dimensions for the blocks used in the construction of the walls. Fig. 5 gives the dimensions for the furring units used on the surfaces of Walls 13a and 14a, and Fig. 6 gives the dimensions for those walls constructed of two monolithic slabs with a sheet of insulating material between. All blocks, with the exception of those for Walls 9a and 12a were machine made. The blocks of these two walls were made by hand tamping, but as the density was higher and the water absorption slightly less than for those blocks which were machine made from similar materials, the hand blocks were considered satisfactory.

The monolithic walls cast with slabs of insulating materials in the center plane, Nos. 38a to 43a, inclusive, were made by pouring two slabs of concrete one 2½ in. and the other 4 in. thick with a sheet of insulating material as specified between the two slabs. The materials used were Thermax, a material made up of shavings imbedded in cement; Multi-cell, made of several layers of corrugated paper cemented together and water-proofed on the outside; Vermiculite, a mineral expanded by heat and mixed with a cement binder to form a slag; vegetable cork, formed in sheets; and a rigid insulating board made of wood fiber. The density, thickness and thermal conductivity of these various materials are shown in Table 6a.

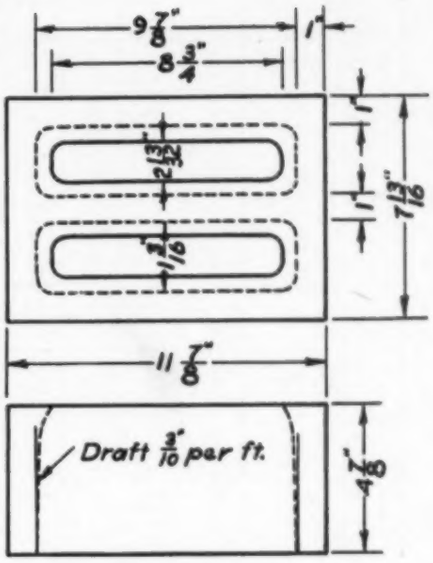

Fig. 2—2 core block 5 in. x 8 in. x 12 in. Used in wall 12a

The forms were built up with reinforcing bars laid for each side of the wall. The reinforcing bars consisted of ⅜ in. bars spaced 15 in. horizontally, 18 in. vertically, and tied together at intersections. The reinforcing structure for the two sides of the wall was tied together with ¼ in. tie rods spaced to give one tie rod for each 4½ sq ft area.

The properties of the insulating material used in the walls are shown in Table 6A. All of these materials except expanded aluminum-magnesium silicate were purchased from stock. The expanded aluminum-magnesium silicate was built up into slabs 1 in. x 12¾ in. x 33 in., consisting of a mixture of six parts expanded-aluminum magnesium silicate and Vulco aggregate to one part of Lumnite cement. The ratio of expanded aluminum-magnesium silicate to Vulco in the aggregate was 1 to 8 by volume. The Vulco was added to increase the strength. This mixture plus water was spread into a frame and subjected to a pressure of approximately 50 lb per square inch. The resulting slab was smooth on the bottom but somewhat rough on the top surface.

In the walls which were built with vapor proof insulating board, corrugated paper, shredded wood and ce-

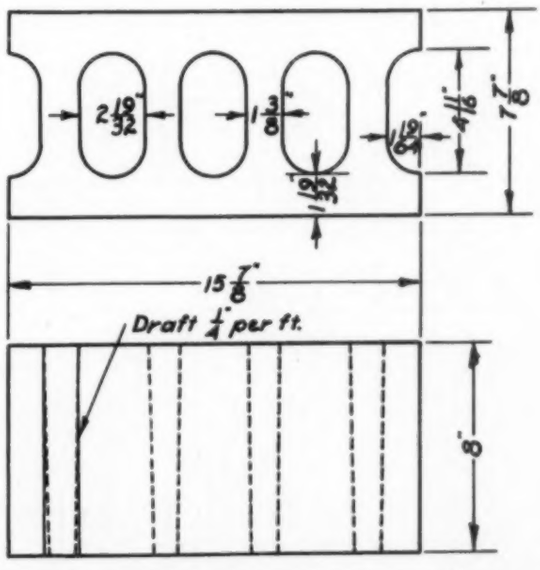

Fig. 3—3 oval core 8 in. x 8 in. x 16 in. Block used in walls 13a, 14a, 2c and 3c

Table 2—Monolithic Walls with Inclosed Insulating Materials—Description and Data

Wall No.	Type of Aggregate	Description of Wall	Density* of Concrete in Wall Lb/Cu Ft	Over-all Thickness of Wall in Inches	Inside Surface Finish	Outside Surface Finish	Additional Insulation in Wall	Density of Insulating Material Lb/Cu Ft	Weight of Insulating Material Per Sq Ft of Wall Area	Aggregate Used in Wall, Per Cent by Weight	Fineness Modulus of Aggregate			Dry Rodded Weight of Aggregate Lb/Cu Ft		Mix Proportion Dry Rodded Volume	Water Cement Ratio W/C Gal/Sack	Slump Inches	28 Day Compressive Strength			Per Cent Absorption at 28 Days	
											Fine	Coarse	Combined	Fine	Coarse				Area of Cylinder Sq In.	Total Breaking Load Lb	Breaking Load Lb/Sq In	By Wt.a	By Vol.a
38a	Sand and Gravel	4 in. Sand and Gravel Concrete, 1 in. Insulating Membrane, 2½ in. Sand and Gravel Concrete	146.0	7.60	As Cast	As Cast	1 in. Rigid Insulation Board	13.2	1.09	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¾	28.27	121,000	4,280	4.85	11.3
38b	Sand and Gravel		146.0	7.60	As Cast	Treated with Fog Spray 1 hour	1 in. Rigid Insulation Board	13.2	1.09	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¾	28.27	121,000	4,280	4.85	11.3
38c	Sand and Gravel		146.0	7.60	As Cast	Treated with Fog Spray 19 hours	1 in. Rigid Insulation Board	13.2	1.09	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¾	28.27	121,000	4,280	4.85	11.3
39a	Sand and Gravel	4 in. Sand and Gravel Concrete, 1 in. Insulating Membrane, 2½ in. Sand and Gravel Concrete	146.0	7.98	As Cast	As Cast	1 in. Rigid Vapor Proof Insulation Board	22.3	1.92	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¼	28.27	123,300	4,360	4.85	11.3
39b	Sand and Gravel		146.0	7.98	As Cast	Treated with Fog Spray 19 hours	1 in. Rigid Vapor Proof Insulad in Board	22.3	1.92	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¼	28.27	123,200	4,360	4.85	11.3
40a	Sand and Gravel		146.0	7.59	As Cast	As Cast	1 in. Cork Board	8.7	0.72	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¼	28.14	119,100	4,230	4.85	11.3
41a	Sand and Gravel		146.0	7.56	As Cast	As Cast	1 in. Water Proof Corrugated Paper	10.0	0.87	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¼	27.76	96,480	3,480	4.85	11.3
42a	Sand and Gravel	4 in. Sand and Gravel Concrete, 2 in. Insulating Membrane, 2½ in. Sand and Gravel Concrete	146.0	8.53	As Cast	As Cast	2 in. Insulation made from Shredded Wood and Cement	29.8	4.96	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¾	28.13	97,510	3,470	4.85	11.3
42b	Sand and Gravel		146.0	8.53	As Cast	Tested with Fog Spray 19 hours	2in. Insulation made from Shredded Wood and Cement	29.8	4.96	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¾	28.13	97,510	3,470	4.85	11.3
43a	Sand and Gravel	4 in. Sand and Gravel Concrete, 1 in. Insulating Membrane, 2½ in. Sand and Gravel Concrete	146.0	7.22	As Cast	As Cast	1 in. Expanded Aluminum-Magnesium Silicate Insulation	46.6	3.87	39 Per Cent Sand 61 Per Cent Gravel	2.96	6.15	4.91	111.0	98.9	1:2:3½	7.0	7¼	28.55	98,480	3,440	4.85	11.3
																Average		7¼	28.19	109,300	3,877		

*Note—Results obtained from Test Cylinder of Wall No. 43a.

ment insulation, and cork there appeared to be a good bond between the insulating material and the concrete. The wall in which untreated insulating board was used showed a crack between the insulating board and concrete around the edges of the wall, and the wall in which expanded aluminum-magnesium silicate was used showed a 1/16 to ⅛ in. irregular crack through the insulation. These cracks were probably due to the fact that the insulation absorbed water at the time the wall was poured, thus increasing the thickness of the insulation during the setting period for concrete. As the insulation was later dried out it shrunk in thickness and either broke the bond between the insulation and the concrete or else split the insulating material. All walls were dried out for a period of 90 days or more before thermal conductivity tests were made.

The samples built up to determine the thermal conductivity of different aggregates, and shown in Table 8, were divided into two groups. For sand and gravel, limestone, cinders and Haydite the percentages between the fine and coarse aggregates were varied, and also the mix was varied to give different slump tests. For samples 1D to 5D the aggregates were graded to give a fineness modulus of 3.75.

Discussion of Results

Several interesting comparisons may be drawn from the final test results for the masonry walls as shown in Tables 5 and 5A. Wall 9a, constructed of 5 in. x 8 in. x 12 in. 2-Core sand and gravel tile was first tested with surfaces as laid, and next as wall 9b with outside surface covered with two coats of waterproof white cement paint. The over-all coefficients were 0.541 and 0.525, respectively, showing a reduction of approximately 3 per cent due to coating the outside surface with paint. In the previous series of tests, 8 in. x 8 in. x 16 in. 3-oval core block walls were tested under similar conditions and showed percentages of reduction in the over-all coefficients of 9.5, 8.3 and 3.5, respectively, for cinder,

Haydite, and sand and gravel block walls. The results for the sand and gravel block walls check in the two series of tests and the percentage reduction is greater for the more porous aggregates, indicating that it is caused largely by a reduction in surface infiltration losses.

The blocks for Walls 9a and 12a were of the same over-all dimensions and built from the same aggregates. The blocks for Wall 9a shown in Fig. 1 were constructed with two rectangular cores extending between the two surfaces with bridge wall between. The blocks for Wall 12a, shown in Fig. 2, were made up with two long rectangular cores running parallel to the surfaces of the block with bridge wall between. Thus the heat passing from surface to surface of Wall 9a travels across one core space, whereas that in passing through Wall 12a travels across two core spaces. The percentage of core volume was 49.3 for Wall 9a and 45.3 for Wall 12a, but the solid material connecting the two surfaces of Wall 9a was greater than for Wall 12a. This is a good illustration of what may be accomplished by the proper arranging of core spaces. The arrangement for the blocks of Wall 12a as compared with those for Wall 9a reduces the core volume, increases the solid cross-sectional material of the block, and therefore increases its compressive strength, decreases the solid material bridging the two surfaces of the wall, and reduces the over-all heat transfer coefficient by 17 per cent.

Walls 13a and 14a were built by using the 8 in. x 8 in. x 16 in. Haydite block wall, No. 2a, as a foundation and adding cinder furring tile for Wall 13a and Haydite furring tile for Wall 14a. The furring tile are shown in Fig. 5. The test results for these walls show an over-all conductivity coefficient of 0.270 for Wall 13a, and 0.281 for Wall 14a, or a reduction of 24 per cent and 21 per cent for the two walls, respectively.

The thermal resistance of an air space may often be improved by filling it with some insulating material. The effectiveness of this treatment will depend not only upon the amount and kind of insulation used but on the shape of the air space and the percentage of total heat which may pass around the air space through the solid section of the wall. For two walls of the same construction, air space insulation will usually be the most effective for that wall having the lower conductivity aggregate. If the wall is so constructed that the path for heat flow around the air spaces is restricted causing a large percentage of the total heat to flow through the air spaces, then insulation should be effective. If, on the other hand, the wall is so constructed that a large percentage of heat may flow directly through the solid material between the air spaces, then the insulation of the air spaces may do but very little good. In order to effectively insulate a wall all paths of heat flow must be considered. For a masonry wall the solid bridges of concrete between the air spaces will carry the heat past the insulation the same as tie rods will carry the heat through the insulation placed between parallel

Table 3—Construction Data for Masonry Walls

Wall No.	Type of Aggregate in Blocks	Aggregate Grading and Average Fineness Modulus	Blocks Manufactured Date	Walls Built Date	Inside Surface Treatment	Outside Surface Treatment	Date of Treatment
9a	Sand and Gravel	Average Fineness Modulus=3.88 Per Cent Passing ½ in...100.0 No. 16..48.1 ⅜ in... 98.2 No. 30..21.1 No. 4.. 74.2 No. 50.. 7.6 No. 8.. 61.9 No. 100.. 0.9	11-8-35 to 11-20-35	1-4-36	None	None	
9b	Sand and Gravel		11-8-35 to 11-20-35	1-4-36	None	2 Coats Water Proof White Cement Paint	2-15-36 2-17-36
11a	Air-Cooled Slag	Average Fineness Modulus=3.92 Per Cent Passing ½ in...100.0 No. 16..40.0 ⅜ in... 93.9 No. 30..27.6 No. 4.. 63.5 No. 50..19.7 No. 8.. 51.3 No. 100..12.0	11-22-35	1-3-36	None	None	
12a	Sand and Gravel	Average Fineness Modulus=3.88 Per Cent Passing ½ in...100.0 No. 16..48.1 ⅜ in... 98.2 No. 30..21.1 No. 4.. 74.2 No. 50.. 7.6 No. 8.. 61.9 No. 100.. 0.9	11-8-35 to 11-20-35	1-3, 4-36	None	None	
13a	Haydite	Average Fineness Modulus=3.92 Per Cent Passing ½ in...100.0 No. 16..38.2 ⅜ in... 93.1 No. 30..21.9 No. 4.. 68.5 No. 50..14.4 No. 8.. 61.7 No. 100..10.0	11-23-34	1-3-35	None	Furred with Cinder Tile—Fig. 5	1-4-36
14a	Haydite		11-23-34	1-3-35	None	Furred with Haydite Tile—Fig. 5	2-8-36
2c	Haydite	Average Fineness Modulus=3.92 Per Cent Passing ½ in...100.0 No. 16..38.2 ⅜ in... 93.1 No. 30=21.9 No. 4.. 68.5 No. 50..14.4 No. 8.. 61.7 No. 100..10.0	11-23-34	1-3-35	None	2 Coats Water Proof White Cement Paint	3-16-35
3c	Sand and Gravel	Average Fineness Modulus=3.91 Per Cent Passing ⅜ in...100.0 No. 30..22.0 No. 4.. 79.4 No. 50.. 5.7 No. 8.. 59.5 No. 100.. 1.3 No. 16. 41.1	11-14-34	1-3-35	None	2 Coats Water Proof White Cement Paint	3-9-35
5b	Cinders	Average Fineness Modulus=4.05 Per Cent Passing ½ in...100.0 No. 16..36.8 ⅜ in... 90.4 No. 50..18.2 No. 4.. 65.1 No. 100.. 9.5 No. 8.. 48.1	11-6-35	1-2-35	None	None	
15a	Haydite	Average Fineness Modulus=3.92 Per Cent Passing ½ in...100.0 No. 16..38.2 ⅜ in... 93.1 No. 30..21.9 No. 4.. 68.5 No. 50..14.4 No. 8.. 61.7 No. 100..10.0	5-9-36	6-6-36	None	None	
15b	Haydite		5-9-36	6-6-36	None	None	

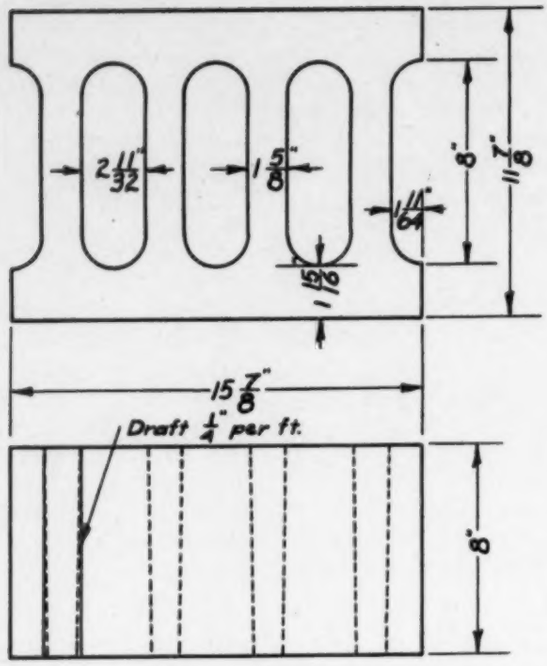

Fig. 4—3 oval core block 8 in. x 12 in. x 16 in. Used in walls 5b, 15a and 15b

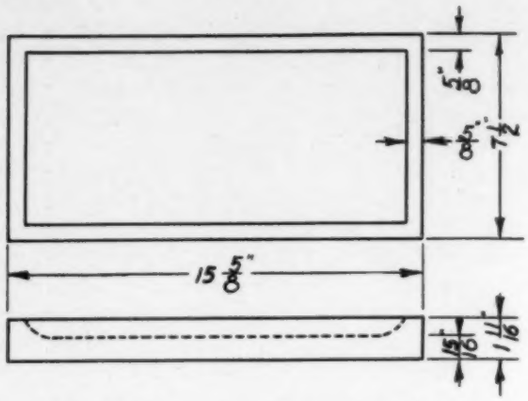

Fig. 5—Furring units used on walls 13a and 14a

masonry or monolithic walls. Since it is necessary to have some bond or tie between the two surfaces of most walls this tie should be built with maximum heat resistance when heat resistance is an important factor.

The combined results for several walls tested with and without insulating the core spaces are shown in Table 5A. Part of these walls were reported in the first paper, but are shown here for comparison. The group contains both 8-in. and 12-in. blocks with cinders, Haydite, and sand and gravel as aggregates for the 8-in. blocks, and cinder and Haydite aggregates for the 12-in. blocks.

Four tests were made on the 8-in. cinder block wall, No. 1b without insulation, and Nos. 1c, 1d and 1e having granulated cork, dry cinders, and Rock Wool in the cores for the respective tests. For each other type of construction two tests were run, one without insulation and the other with granulated cork in the core spaces. The fifth from the last column of Table 5A gives the conductivity coefficients corrected to a 15-mile wind velocity over the outside surface. The third from the last column gives the percentage improvement due to insulating the core spaces and shows the important factor in determining whether or not it is worth while to insulate the wall. The last column gives the effectiveness of the insulating material as used. The values in this column were obtained by assuming that the insulating material used was spread evenly over the full surface of the wall, and then calculating the effective conductivity of this material from the test results for the wall with and without insulation in the core spaces. The high calculated effective values for these materials compared with their actual thermal values is due to the fact that in the test the heat passed around the air spaces regardless of how thoroughly they may have been insulated. A comparison of the results for Walls 1c, 2c and 3c illustrates the fact that the effectiveness of air space insulation is much greater for those walls built of low conductivity aggregates. Thus, granulated cork in a Haydite block gives 1.12, or slightly better than the value of 1.38 when used in a cinder block, but for sand and gravel blocks the effective conductivity is 4.63.

A comparison of the results for the 8-in. and 12-in. masonry walls without insulation in the core spaces shows that for the low conductivity aggregates there is but little difference between the over-all coefficients as obtained for the 8-in. and 12-in. walls. The 8-in. x 8-in. x 16-in. cinder block wall, No. 1a, gave an over-all conductivity coefficient of 0.396 as compared with 0.374 for the

Table 4—Construction Data for Double Monolithic Walls With Inclosed Insulating Materials

Wall No.	Type of Insulation	Type of Aggregate in Wall	Grading of Aggregate and Average Fineness Modulus	Mix Proportions by Volume and Kind of Mix	No. of Lifts Required for Pouring Wall	Date of Building Wall
38a	1 in. Rigid Insulation Board	Sand and Coarse Gravel Concrete	Fineness Modulus of Combined Aggregate=4.91 Per Cent Passing Fine: ⅜ in. 100.0; No. 4 99.7; No. 8 90.2; No. 16 70.0; No. 30 40.0; No. 50 1.9; No. 100 1.0 Coarse: ¾ in. 100.0; ⅜ in. 66.0; No. 4 14.5; No. 8 2.0; No. 16 0.8; No. 30 0.6; No. 50 0.4; No. 100 0.4	1:2:3½ Plastic Mix	4	6-10-35
39a	1 in. Rigid Vapor Proof Insulation Board	Sand and Coarse Gravel Concrete		1:2:3½ Plastic Mix	4	6-11-35
40a	1 in. Corkboard	Sand and Coarse Gravel Concrete		1:2:3½ Plastic Mix	4	6-12-35
41a	1 in. Water Proof Corrugated Paper	Sand and Coarse Gravel Concrete		1:2:3½ Plastic Mix	4	7-30-35
42a	2 in. Insulation made from Shredded Wood and Cement	Sand and Coarse Gravel Concrete		1:2:3½ Plastic Mix	4	8-2-35
43a	1 in. Expanded Aluminum-Magnesium Silicate and Cement Binder	Sand and Coarse Gravel Concrete		1:2:3½ Plastic Mix	4	11-15-35

12-in. cinder block wall, 5a. When the outside surface of the 8-in. cinder block wall, 1a, was painted to give Wall 1b, the coefficient was brought down equal to 0.374, or equal to that of the 12-in. wall. The 8-in. uninsulated Haydite wall, 2a, gave a coefficient of 0.357, and the uninsulated 12-in. Haydite wall, 15a, gave a coefficient of 0.342. Two coats of white cement paint on the 8-in. Haydite wall brought the coefficient down to 0.334, which is less than that for the 12-in. wall. When the core spaces of these two walls were filled with cork the conductivity values were 0.172 for the 8-in. wall, No. 2c, and 0.148 for the 12-in. wall, No. 15b.

An inspection of the drawings giving the cross-sectional view of the 8-in. and 12-in. blocks shows the thickness of solid material between the cores of the 8-in. block to be 1⅜ in. and that between the core spaces of the 12-in. blocks to be 1⅝ in. There is, thus, a slightly larger cross-sectional area of solid material connecting the two surfaces of the 12-in. blocks than that connecting the two surfaces of the 8-in. block. The length of path for heat flow through the solid partition of the 8-in. block is 4 11/16 in. whereas that for the 12-in. block is 8 in. For the same temperature difference the amount of heat conducted through the solid material for each block would be proportional to the area and inversely proportional to the length of path of solid material, and if there was no

Table 5—Test Data and Results for Masonry Walls

Wall No.	Test No.	Date of Test	Description of Wall	Inside Surface Finish	Outside Surface Finish	Additional Insulation in Walls	Air Temperature F			Coefficients of Heat Transmission		
							High Side	Low Side	Mean Temp.	*C*	*U*	*U* Corrected to 15 mph Wind Vel.
9a	48	2–12–36	5 in. x 8 in. x 12 in. 2-Core Sand and Gravel Tile	As laid	As laid	None	79.36	0.5	39.93	0.947	0.430	0.541
9b	53	2–25–36	5 in. x 8 in. x 12 in. 2-Core Sand and Gravel Tile	As laid	2 Coats Water Proof White Cement Paint	None	79.97	0.14	40.05	0.899	0.420	0.525
11a	51	2–20–36	8 in. x 8 in. x 16 in. 3-Oval Core Air Cooled Slag Block	As laid	As laid	None	79.95	0.16	40.06	0.677	0.364	0.441
12a	50	2–18–36	5 in. x 8 in. x 12 in. Blystone Tile Sand and Gravel Block	As laid	As laid	None	79.72	0.39	40.05	0.735	0.380	0.465
13a	47	1–29–36	8 in. x 8 in. x 16 in. 3-Oval Core Haydite Block	As laid	Furred with Cinder Tile—Fig. 5	None	80.17	—0.21	39.98	0.343	0.239	0.270
14a	54	2–27–36	8 in. x 8 in. x 16 in. 3-Oval Core Haydite Block	As laid	Furred with Haydite Tile—Fig. 5	None	80.84	—0.70	40.07	0.362	0.248	0.281
2c	57	6–19–36	8 in. x 8 in. x 16 in. 3-Oval Core Haydite Block	As laid	2 Coats Water Proof White Cement Paint	Cores Filled with Granulated Cork	80.68	—0.38	40.15	0.199	0.159	0.172
3c	55	6–10–36	8 in. x 8 in. x 16 in. 3-Oval Core Sand and Gravel Block	As laid	2 Coats Water Proof White Cement Paint	Cores Filled with Granulated Cork	80.01	0.4	40.02	0.542	0.321	0.379
5b	56	6–17–36	8 in. x 12 in. x 16 in. 3-Oval Core Cinder Block	As laid	As laid	Cores Filled with Granulated Cork	80.58	—0.15	40.22	0.237	0.182	0.199
15a	59	7–12–36	8 in. x 12 in. x 16 in. 3-Oval Core Haydite Block	As laid	As laid	None	79.96	—0.27	39.85	0.468	0.294	0.342
15b	60	7–15–36	8 in. x 12 in. x 16 in. 3-Oval Core Haydite Block	As laid	As laid	Cores Filled with Granulated Cork	80.70	—0.46	40.12	0.168	0.139	0.148

Table 5A—Insulation Placed in the Core Spaces of Masonry Walls

Wall No.	Description of Wall	Outside Surface Treatment	Insulation in Core Spaces	Density of Insulation Lb/Cu Ft	Lb Insulation/Sq Ft Wall Area	Equivalent Thickness of Insulation Over Wall Surface	Over-all Coeff. *U* for 15 Miles Wind Velocity	Over-all Resistance 1/*U*	Per Cent Improvement in Over-all Coeff. *U* for Walls Tested	Gain in Resistance Due to Insulation	Effective Conductivity *k* for Insulating Material
1a		As Laid	None				0.396	2.52			
1b	8 in. x 8 in. x 16 in.	Painted	None				0.370	2.70	6.66	0.18	
1c	3-Oval Core	Painted	Granulated Cork	5.12	1.34	3.15	0.201	4.97	45.7	2.27	1.38
1d	Cinder Block	Painted	Dry Cinders	69.70	18.29	3.15	0.283	3.53	23.5	0.83	3.79
1e		Painted	Rock Wool	14.21	3.72	3.15	0.211	4.74	43.0	2.04	1.54
2a	8 in. x 8 in. x 16 in.	As Laid	None				0.354	2.82			
2b	3-Oval Core	Painted	None				0.354	2.99	5.69	0.17	
2c	Haydite Block	Painted	Granulated Cork	5.06	1.33	3.15	0.172	5.81	48.5	2.82	1.12
3b	8 in. x 8 in. x 16 in. 3-Oval Core Sand and Gravel Block	As Laid	None				0.509	1.96			
3c		As Laid	Granulated Cork	5.14	1.35	3.15	0.379	2.64	25.5	0.68	4.63
5a	8 in. x 12 in. x 16 in. 3-Oval Core Cinder Block	As Laid	None				0.374	2.67			
5b		As Laid	Granulated Cork	5.24	2.10	4.81	0.199	5.03	46.8	2.36	2.04
15a	8 in. x 12 in. x 16 in. 3-Oval Core Haydite Block	As Laid	None				0.342	2.92			
15b		As Laid	Granulated Cork	5.60	2.38	5.10	0.148	6.76	56.7	3.84	1.33

heat conducted through the air spaces the heat flow through the 12-in. block would be 0.7 of that conducted through the 8-in. block. Since there is a much greater percentage transferred through the 12-in. block the rate of flow through the air spaces for the 12-in. block must be greater than the rate of flow through the air spaces of the 8-in. block. This increase may be accounted for by the sizes and shape of the air spaces. Since the air spaces are really in the form of narrow slots passing through from surface to surface of the blocks, the solid partition walls bounding these air spaces transfer heat to and from the air in the spaces and actually increase the rate of heat transfer through the air space. This heat transfer from the solid material to the air would normally continue to the central plane of the wall from which point on there would be a transfer from the air to the solid material, and the total amount of heat transferred through the air space would be increased by additional convection currents. The percentage increase in heat transfer would be greater for the longer air space of the 12-in. block than for the shorter air space of the 8-in. block. Thus the air space of the 12-in. block actually conducts more heat from surface to surface of the wall than does the air space of the 8-in. block.

In the first series of tests the use of dry insulating material was investigated when placed between two parallel concrete walls. A 1-in. air space between two masonry walls built up of 4-in. partition tile was filled with Rock Wool and the 2½-in. air space between two monolithic sand and gravel walls was filled first with dry cinders and next with Rock Wool. The results of these tests are shown in Table 10 of the previous report and indicate that when insulation is so used the tie rods or bonds between the two walls must be considered. In the present series of tests six double monolithic walls were built with various types of insulating materials between the slabs.

Table 6—Test Data and Results for Double Monolithic Walls With Inclosed Insulating Materials

Wall No.	Test No.	Date of Test	Description of Wall	Inside Surface Finish	Outside Surface Finish	Additional Insulation in Walls	Air Temperature F			Coefficients of Heat Transmission		
							High Side	Low Side	Mean Temp.	*C*	*U*	*U* Corrected to 15 mph Wind Vel.
38a	39	12-14-35	4 in. sand and gravel concrete, 1 in. rigid insulating membrane, 2½ in. Sand and Gravel Concrete	As Cast	As Cast	1 in. Rigid Insulation Board	79.99	+0.15	40.07	0.325	0.230	0.258
38b	43	12-31-35		As Cast	Treated with Fog Spray 1 hour Wall absorbed 12.5 lb water or 0.5 per cent by Wt. of Wall		80.21	—0.136	40.04	0.325	0.230	0.258
38c	44	1-4-36		As Cast	Treated with Fog Spray 19 hours. Wall absorbed 29 lbs water or 1.16 per cent by Wt. of Wall		80.16	—0.15	40.01	0.321	0.228	0.256
39a	40	12-18-35	4 in. Sand and Gravel Concrete, 1 in. Insulating Membrane, 2½ in. Sand and Gravel Concrete	As Cast	As Cast	1 in. Vapor Proof Rigid Insulation Board	81.19	—1.30	39.95	0.335	0.235	0.265
39b	46	1-10-36		As Cast	Treated with Fog Spray 19 hours. Wall absorbed 32 lb Water or 1.24 per cent by Wt. of Dry Wall		80.20	—0.17	40.01	0.331	0.233	0.262
40a	38	12-10-35	4 in. Sand and Gravel Concrete, 1 in. Cork-Board, 2½ in. Sand and Gravel Concrete	As Cast	As Cast	1 in. Cork Board	80.04	+0.12	40.08	0.360	0.247	0.280
41a	41	12-27-35	4 in. Sand and Gravel Concrete, 1 in. Water Proofed Corrugated Paper, 2½ in. Sand and Gravel Concrete	As Cast	As Cast	1 in. Water Proofed Corrugated Paper	81.15	—1.06	40.05	0.360	0.247	0.280
42a	42	12-29-35	4 in. Sand and Gravel Concrete, 2 in. Insulation, made from Shredded Wood and Cement 2½ in. Sand and Gravel Concrete	As Cast	As Cast	2 in. Insulation made from Shredded Wood and Cement	80.41	—0.28	40.07	0.377	0.255	0.290
42b	45	1-7-36		As Cast	Treated with Fog Spray 19 hours. Wall absorbed 26 lb of Water or 1.0 per cent by Wt. of Dry Wall		80.11	—0.23	39.94	0.366	0.250	0.284
43a	49	2-14-36	4 in. Sand and Gravel Concrete, 1 in. Expanded Aluminum-Magnesium Silicate and Cement Binder, 2½ in. Sand and Gravel Concrete	As Cast	As Cast	1 in. Expanded Aluminum-Magnesium Silicate and Cement Binder	79.34	+0.47	39.91	1.083	0.456	0.583

Table 6A—Hot Plate Test Data and Results for the Insulating Materials Inclosed Within the Double Monolithic Walls of Table 6

Wall No.	Test No.	Date of Test	Type of Insulation	Density	Thickness	Temperature				*C*	*K*
						Hot Side	Cold Side	Temp. Diff.	Mean Temp.		
38a	1182	7-1-35	Rigid Insulation Board	13.2	0.995	113.12	36.30	76.82	74.71	0.344	0.343
39a	1196	11-27-35	Vapor Proof Rigid Insulation Board	22.3	1.034	112.7	37.8	74.9	75.25	0.388	0.401
40a	1194	10-10-35	Corkboard	8.7	0.993	94.0	54.7	39.3	74.35	0.289	0.287
41a	1216	3-13-36	Water Proof Corrugated Paper	10.0	1.046	114.75	35.55	79.20	75.15	0.366	0.383
42a	182[b]	5-19-36	Insulation made from Shredded Wood and Cement	29.8	2.001	91.55	62.90	28.65	77.22	0.385	0.770
43a	1221	6-21-36	Expanded Aluminum-Magnesium Silicate and Cement Binder	46.6	0.997	104.07	34.15	69.92	74.11	1.186	1.182

[b]—24 in. Hot Plate.

The over-all test results for these walls are shown in Table 6, the hot plate test for the insulating materials in Table 6A, and the summary of the test results on the walls as built compared with calculated results in Table 7. In constructing these walls the area of tie rods was reduced to a minimum, thus giving an effective conductivity for the insulating material only slightly higher than the true value. The last column of Table 7 gives the percentage difference between calculated and test values and shows a substantial agreement for the values of Wall 39a in which a vapor proof insulating board was used. In this case there was a close bond between the insulating material and concrete, and since the board was vapor proof there was no absorption of water to change its thickness or insulating properties. In Wall 38a an untreated insulating board was used which did absorb some water, although in this case the calculated and test values were reasonably close together. For Wall 40a, 1-in. cork board was used, which was rather rough on the surface, permitting the mortar to enter the board, and thereby decrease its heat resistance. A 19 per cent increase in test value over calculated value shows the effect of this mortar. The insulation in Wall 41a was built up of several layers of corrugated paper having a water proofed surface. In this case the surface of the material was rather soft and the hydraulic pressure of the cement and mortar had a tendency to slightly crush the surface, thereby reducing the effectiveness of the insulation for the finished wall. The insulation, made from shredded wood and cement, used in Wall 42a was of rough and uneven surface, which would allow the entrance of mortar, but in this case the insulating material was 2 in. thick. Therefore the percentage effect due to mortar entering the insulating material was less than for the rough surface of the 1-in. cork. The expanded aluminum-magnesium silicate insulating slab used in Wall 43a absorbed water readily and was materially affected by the wet mortar. These results indicate that if the conductivity of the insulation is corrected for the effect of tie rods, and the surface characteristics of the insulating materials are considered, the over-all coefficients for insulated monolithic wall can be calculated with reasonable accuracy.

The thermal conductivity of monolithic concrete depends largely upon the density of the final concrete, which in turn depends upon the aggregates used, and the amount of water used in the mix. The physical data for aggregates indicates that lower density is obtained with an increase in the water-cement ratio and therefore the thermal conductivity was reduced. The

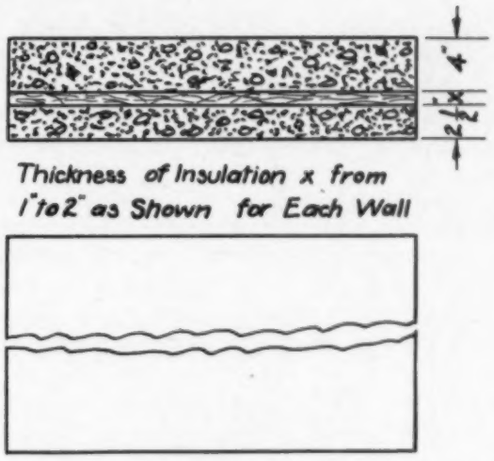

Fig. 6—Detail of monolithic walls with insulation between 2 slabs

thermal conductivity for six monolithic walls was determined in the first series of tests and the results shown in Table 7 of the first report. The thermal conductivity of nine different aggregates using various mixes was investigated in this series of tests and the results are shown in Table 8. From this table it will be noted that for the same aggregate and for the same slump test there are some differences in density caused by the different grading of the aggregates. These variations in density are, however, not uniform throughout the range. For a given aggregate the conductivities obtained are usually directly proportional to the density. For sand and gravel and limestone aggregates the dry mixes give a denser concrete with higher conductivities. Thus, the dry tamp mix wall, No. 32 of the previous series of tests, gave a conductivity k of 13.1, while the plastic mix, wall No. 31a of the same series, gave a thermal conductivity k of 12.4. The densities were 148.8 and 143.3 respectively. From Table 8 the averages for six sand and gravel samples with zero slump were $k = 13.1$, density 145 lb per cubic foot; and for six samples of 5-in. slump $k = 12.4$, density 141.1 lb per cubic foot. This shows a very close agreement between the conductivity as obtained by the hot plate and hot box method and sets the average value for sand and gravel concrete from 12.4 to 13.1. Three limestone aggregates of zero slump, Table 8, gave an average conductivity of 11.56 at an average density of 136.5 lb per cubic foot, and three samples of 3-in. slump gave an average of 10.08 for conductivity, with 127.8 for density.

Sand and limestone plastic mix wall No. 30a gave a

Table 7—Comparative Values of Computed and Experimental Over-All Coefficient of Heat Transmission for Double Monolithic Walls with Inclosed Insulating Materials

Wall No.	Thickness Data Inches			Thermal Conductivity K			Coefficients of Heat Transmission							
	Wall	Concrete	Insulation	Concrete[c]	Insulation		f_{ie}	f_{oc}	Calculated Values		Experimental Values		Per Cent Diff.	
					Hot Plate Value	Corrected for Tie Rods			C	U	C	U	C	U
38a	7.60	6.60	0.995	12.0	0.343	0.368	1.60	1.55	0.307	0.221	0.325	0.230	5.5	3.9
39a	7.98	6.95	1.034	12.0	0.401	0.426	1.60	1.55	0.333	0.234	0.335	0.235	0.6	0.4
40a	7.59	6.60	0.993	12.0	0.287	0.312	1.60	1.55	0.268	0.200	0.360	0.247	25.5	19.0
41a	7.56	6.51	1.046	12.0	0.383	0.408	1.60	1.55	0.322	0.229	0.360	0.247	10.5	7.3
42a	8.53	6.53	2.001	12.0	0.770	0.795	1.60	1.55	0.327	0.231	0.377	0.255	13.3	9.4
43a	7.22	6.22	0.997	12.0	1.182	1.207	1.60	1.55	0.744	0.382	1.053	0.456	31.3	16.2

c—Assumed.

Table 8—Data and Test Results for 24 in. x 24 in. x 2 in. Concrete Specimens

Designation on Samples	Physical Data: Type of Aggregate	Mix Proportions by Volume: Cement	Fine Aggregate 0-No. 4	Coarse Aggregate No. 4-½ in.	Slump Inches	Density of Concrete Bone Dry Lb/Cu Ft	Per Cent Absorption: By Wt.	By Vol.	Per Cent of Voids By Vol.	Hot Plate Data: Test No.	Density as of Test Lb/Cu Ft	Thickness Inches	Temperatures: High Side	Low Side	Temp. Diff.	Mean Temp.	Coefficients of Heat Transmission: C	K
S-1-0	Sand and Gravel	1	2.00	2.75	0	144.7	4.7	10.9	11.5	143	150.2	1.995	87.51	62.61	24.90	75.06	6.558	13.1
S-2-0		1	2.75	4.50	0	145.7	4.5	10.4	10.9	146	150.1	1.990	87.87	61.67	26.20	74.77	6.507	12.9
S-3-0		1	3.50	5.50	0	144.5	4.7	10.8	11.2	144	148.1	1.992	88.45	61.55	26.90	75.00	6.606	13.2
S-1-5		1	2.00	2.75	5	142.5	5.9	13.4	13.9	147	148.2	1.988	89.28	61.72	27.56	75.50	6.099	12.1
S-2-5		1	2.75	4.50	5	142.5	5.9	13.4	13.9	177	148.2	1.988	81.89	67.59	14.30	74.74	6.228	12.4
S-2-5		1	2.75	4.50	5	141.1	6.3	14.2	14.6	142	146.4	1.985	86.9	59.7	27.2	73.3	6.256	12.4
S-3-5		1	3.50	5.50	5	139.2	6.5	14.4	14.7	153	146.4	1.985	88.79	60.98	27.81	74.89	6.092	12.1
S-3-5		1	3.50	5.50	5	139.2	6.5	14.4	14.7	145	144.7	1.982	87.55	61.44	26.11	74.50	6.485	12.85
S-3-5		1	3.50	5.50	5	139.2	6.5	14.4	14.7	165	144.7	1.982	86.67	63.64	23.03	75.15	6.293	12.5
L-1-0	Limestone	1	2.00	2.75	0	135.3	7.4	16.0	16.6	155	141.0	1.985	90.06	59.68	30.38	74.87	5.670	11.2
L-2-0		1	2.75	4.50	0	137.8	6.7	14.8	15.4	152	143.3	1.992	89.50	60.86	28.64	75.18	6.029	12.0
L-3-0		1	3.50	5.50	0	136.4	7.2	15.7	16.3	154	141.7	1.996	89.08	60.41	28.67	74.75	5.775	11.5
L-1-3		1	2.00	2.75	3	130.1	9.8	20.4	20.9	156	136.3	1.980	89.41	60.31	29.10	74.86	5.294	10.5
L-2-3		1	2.75	4.50	3	126.0	11.4	23.0	23.4	150	132.6	1.983	88.28	60.61	27.67	74.45	5.070	10.0
L-3-3		1	3.50	5.50	3	127.3	11.4	23.1	23.4	157	133.3	1.983	90.41	60.11	30.30	75.26	4.939	9.79
C-1-0	Cinders	1	2.00	2.75	0	103.6	10.5	17.4	18.2	166	110.0	2.038	95.19	55.33	39.86	75.26	2.272	4.63
C-2-0		1	2.75	4.50	0	98.7	12.1	19.1	19.9	167	103.9	2.040	97.32	54.11	43.21	75.71	2.106	4.30
C-3-0		1	3.50	5.50	0	92.0	13.8	20.2	21.4	168	97.0	2.041	98.09	53.36	44.73	75.72	1.829	3.73
C-1-3		1	2.00	2.75	3	101.4	13.8	22.5	22.8	170	110.0	2.028	93.89	56.01	37.88	74.95	2.412	4.89
C-2-3		1	2.75	4.50	3	94.0	17.0	25.6	26.0	149	101.9	2.032	99.27	51.14	48.13	75.20	2.156	4.38
C-3-3		1	3.50	5.50	3	94.4	16.0	23.9	24.4	169	101.5	2.039	96.48	54.63	41.85	75.55	2.080	4.24
H-1-0	Haydite	1	2.00	2.75	0	80.7	13.5	17.5	18.0	158	87.7	2.023	96.87	52.77	44.11	74.82	2.050	4.15
H-2-0		1	2.75	4.50	0	75.0	16.2	19.4	19.8	161	81.2	2.034	98.64	52.87	45.77	75.75	1.859	3.78
H-3-0		1	3.50	5.50	0	71.7	18.6	21.3	21.8	159	78.4	2.030	96.69	52.94	43.75	74.82	1.810	3.67
H-1-4		1	2.00	2.75	4	78.8	16.5	20.8	21.2	163	88.9	2.019	94.68	54.84	39.84	74.76	2.170	4.38
H-2-4		1	2.75	4.50	4	72.4	18.8	21.8	22.2	148	80.7	2.017	100.51	50.27	50.24	75.39	1.931	3.89
H-2-4		1	2.75	4.50	4	72.4	18.8	21.8	22.2	162	80.7	2.017	96.72	54.26	42.46	75.49	1.913	3.86
H-3-4		1	3.50	5.50	4	71.0	20.3	23.0	23.9	160	80.3	2.018	97.16	53.75	43.41	75.45	1.980	4.00
1D	40 Percent Expanded Burned Clay, 60 Per Cent Fine Haydite	1	8.00	Fineness Modulus 4.50		57.9	18.2	16.8	18.4	175	59.9	2.014	93.09	58.05	35.04	75.57	1.134	2.28
2D	Steam Treated Limestone Slag	1	7.00	Fineness Modulus 4.03		74.6	14.7	17.6	27.1	173	77.5	2.013	94.91	54.06	40.85	74.49	1.128	2.27
3D	Steam Treated Slag obtained as By-Product of Mfg. of Phosphates	1	8.00			86.6	10.8	15.0	25.5	172	89.0	2.019	94.11	55.12	38.99	74.62	1.579	3.19
3DA		1	8.00			91.1	10.5	15.3	21.1	171	93.4	2.034	92.71	56.15	36.56	74.43	1.683	3.42
4D	Pumice Mined in California	1	8.00			65.0	20.1	20.9	26.5	174	69.15	2.024	94.05	55.30	38.75	74.68	1.195	2.42
5D	Haydite	1	8.50			67.1	17.7	18.9	21.8	164	70.45	2.024	98.96	52.82	46.14	75.89	1.427	2.89
5D		1	8.50			67.1	17.7	18.9	21.8	178	70.45	2.024	87.46	61.90	25.56	74.68	1.391	2.815

conductivity of 12.1 with a density of 140.3. The fact that the conductivity value for this wall is higher than for these samples tested by the hot plate method is due to the fact that sand was used in the aggregate for the wall, giving a more dense concrete. If the conductivities for the three tests on sand and limestone aggregates are plotted against densities, the results will fall on a straight line. For the cinder and Haydite aggregates the relation between density and plasticity of mix is not as definite as with sand and gravel and limestone aggregates and probably is affected more importantly by the degree of compaction of the mix in the mold. For the cinder aggregates, Table 8, the average density of three zero slump samples is 98.1 lb per cubic foot, with a conductivity k of 4.22; and the average of three 3-in. slump samples is 96.6 lb per cubic foot with a conductivity k of 4.45. The density relations are the same as for the other concrete samples, but the conductivities of the samples do not follow the density. This difference is small and might be accounted for by the fact that the surfaces of these samples were rough and test results were more difficult to obtain. For Haydite aggregates the

averages for three samples with zero slump were density 75.8, conductivity $k = 3.87$. For four samples of 4-in. slump the averages were density 76.1, conductivity $k = 3.78$. These results are substantially the same as for the cinder aggregates, indicating that for the lower density aggregates such as cinders and Haydite the plasticity of mix is not as important a factor in determining the density and the conductivity as it is for sand and gravel or for limestone aggregates.

Acknowledgment

The authors wish to acknowledge the assistance of R. E. Copeland of the *Portland Cement Association* in selecting typical aggregates, types of construction, and in working out the program in general.

Eliminating Occupational Disease Hazards

At the 25th National Safety Congress and Exposition held in Atlantic City, October 5-9, R. C. Stratton* stated that the engineer must rely upon the medical director to select individuals capable of working in hazardous occupations, and to assist him in controlling these individuals through periodical physical examinations when the men are exposed to occupational disease hazards; but the engineer alone is responsible for reducing the harmful substances and for the control of employees' contact with processes using harmful materials.

The engineer today is confronted with the most confusing and the most perplexing problem. While it has many aspects other than engineering, yet engineering provides the answer to the principal factors involved in the prevention of diseases attributed to exposure within the industry. The engineer generally works with materials which he can see, but the study of industrial disease control may require the handling of invisible materials. Today safety engineers and industrial hygienists are concentrating their attention upon diseases caused by the inhalation of dust.

While the problem confronting individual safety engineers varies according to the industry, there are certain fundamentals common to all such problems which provide a workable basis upon which an occupational disease prevention program may be developed. The fundamentals follow this sequence: 1. An occupational disease inventory is required; 2. A plan for correction of the exposures shown by the inventory requires development; and 3. A concentrated attack upon the major exposures first, following through until all are corrected or eliminated.

Housing—One of the most important considerations in attempting to control occupational disease is housing. Whenever practical, any hazardous manufacturing process should be separately housed and isolated, and buildings should be so constructed that accumulation of dust may be avoided. When physical separation of departments is required, such divisions should be dust or vapor tight. Floors should be tight to prevent transfer of materials to floors or departments below. The engineer should give study to the complete enclosure of machinery or process units as individual units, and if so required, vent each one separately.

Process Revision—To reduce transportation of materials and exposure to harmful substances, it is desirable to have all processes mechanically continuous and if possible enclosed. The engineer should consider the substitution of wet processes for dry processes providing at the same time for the disposal of the moist collected material in a safe place.

Ventilation—Proper ventilation is of paramount importance. If ventilating equipment can reduce the concentration of contaminating materials to a safe limit, the problem is solved. It is seldom wise to rely upon general ventilation. Instead, high velocity ventilating apparatus should be installed functioning as closely to the point of generation of the harmful substance as is possible. Down-draft systems should be preferred for the collection of dust or gases of high specific gravity. The engineer must exercise extreme care to provide a clean source of replacement air for the work place. Frequently it is necessary to install filtering and heating devices and particularly must the engineer study the proper disposal of the collected or expelled material to be positive it will not drift back to the work place.

Employee Protection—While the primary engineering means of protection against possible occupational diseases should be mechanical correction, the engineer will find instances where even the best systems must be supplemented by individual protection. He must carefully study such exposures to provide the highest efficiency of protection yet obtain a device easy for the operator to wear continuously. When the engineer has been successful in obtaining such a device, he must educate workers to use it.

Sanitation—Clean washing facilities and toilets should be provided. Luncheon rooms should be not only clean but also well lighted and attractive and should be under the supervision of the plant physician.

Scientific Tests—The engineer interested in ascertaining not only exposure but also efficiency of control should realize control cannot be fully effective nor the efficiency of any protective device determined without scientific tests. He must be familiar with dust counting, air sampling and chemical analysis technique, having such determinations made by established and proper methods. If such tests are beyond the scope of the engineer's ability or equipment and if he considers such tests absolutely essential, permission should be granted to obtain experts qualified to make such surveys as the problem may require. The need for accurate engineering approach to any control measure cannot be over-emphasized.

Conclusion—The control of any industrial disease exposure is divided, part of such control falling within the jurisdiction of the industrial physician and part within the engineering province. Medical knowledge is invaluable in the detection of early symptoms and in the administration of suitable preventive treatment. The engineer should obtain the services of an industrial physician to make a study of the plant, to assist in the classification of the hazardous operations and working locations and by such coordination the control of the exposure will be facilitated.

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*Supervising Chemical Engineer, The Travellers Insurance Co., Hartford, Conn.

Application of Electric Water Heaters to Domestic Service

By C. G. Hillier* (*NON-MEMBER*), Mansfield, Ohio

THE application of electricity to water heating is perhaps in much greater general use than a great many people appreciate, and this is particularly true of water heating for domestic use.

In industry there are a great many applications of electricity to water heating, but in general, these are special applications or applications embodying special features to which electricity as an energy lends itself most readily, due to its possible close temperature control, the confining of heat to certain locations and the absence of combustion with its inherent flame, fumes and smoke.

In the domestic field, particularly during the last four or five years, there has been a large increase in the number of electric water heaters installed in American homes. Approximately 50 per cent of all of the domestic users of electrical energy now have special water heating rates available that make electric water heating for domestic use economical.

Electric Rates

It is generally conceded at the present time that electricity for water heating must sell at approximately one cent per kilowatt hour to make it an economical operation and as a result, the majority of rates average approximately one cent per kilowatt hour for water heating, although the actual kilowatt hour charges in some cases run as low as 8 mills.

In establishing water heating rates, the various electric utilities have had to consider the type of service rendered and as a result, some electric companies furnish this low cost current throughout the full 24 hours per day, while other utilities experiencing heavy peak load demands, at certain hours of the day, have established controlled service, otherwise known as off-peak service. Insofar as the ultimate consumer is concerned, if the proper size of storage tank is installed, the customer or consumer will enjoy equally satisfactory service whether that service be on a 24-hour basis or on an off-peak basis.

Where off-peak current is sold, the initial cost of equipment to the consumer is slightly higher, due to the fact that larger storage capacity is required. However, the difference between the cost of the various sizes of storage tanks is relatively small, therefore, this matter of initial expense is not a major one.

Types of Electric Heaters

Electric water heaters generally fall in one of three classes, namely, the side-arm heater, the strap-on or the immersion type. The side-arm heater is quite similar in its application to the common inexpensive side-arm gas heater where pipes are connected to the tank and to the electric heater and the tank is heated by the water flowing through the electric heater back into the tank. This type of heater is less popular today than it was several years ago and its present-day applications are confined largely to special applications requiring intermittent service rather than full 24-hour, hot water service.

The strap-on heater elements are clamped on to the tank after which the entire unit is covered with an insulation. With the strap-on heater, 24-hour service may be maintained the same as with the immersion type unit, although generally the strap-on type is not considered quite as efficient as the immersion type where the heating elements are immersed directly in the water within the tank.

The immersion heater type of storage electric water heater is the most commonly used. The heating elements are immersed directly within the tank and fastened to the tank usually by the bolted flange method. Usually two heating elements are used, one installed near the bottom of the tank and the other from ¼ to ⅓ of the distance down from the top of the tank. Each heating element is controlled by a separate thermostat and normally the bulk of the heating is done by the lower heating element, the top heating element acting principally as an emergency unit to cut into the circuit when abnormal amounts of water are required or when the top portion of the tank is cold. The top heating element insures reasonable quantities of water being delivered quickly in the event of abnormal or heavy draw-offs of hot water.

The two heater type of tank lends itself to a combination of 24-hour and off-peak service, in that the bottom heating element, in order to earn the lowest possible electric rate, may be out of service during the hours when the central station has a peak demand for current for other purposes. In such cases, the top heating element is connected to the regular house meter insuring the user of no interruption in hot water service. Under such circumstances, the top heating element is usually metered on the regular house meter at a slightly higher rate of current charge. Tanks equipped with two heating elements as previously described are recommended because generally speaking they will render a more satisfactory service.

In the factory built storage type water heater, various means have been adopted to prevent excessive mixing of the cold water entering the tank with the hot water in the tank and by such means it has been possible to develop a more efficient unit.

The temperature of water delivered at various rates of flow from a 52-gal storage type water heater is shown in Fig. 1. This test was conducted by heating the entire tank until the thermostats opened the electric circuits

*Manager Water Heater Division, Westinghouse Electric and Manufacturing Co.

and then starting the water flowing at a uniform speed without further electricity being applied to the tank.

The beneficial effect of baffling the cold water on an actual installation where the tank was heated during the night, but with no energy applied during the day is illustrated in Fig. 2. On this particular day, between 6:00 a.m. and 10:30 p.m., 50 gal of water were withdrawn from this 52-gal capacity tank. The last 10 gal draw-off at 10:30 p.m. shows an average temperature of 125.9 F.

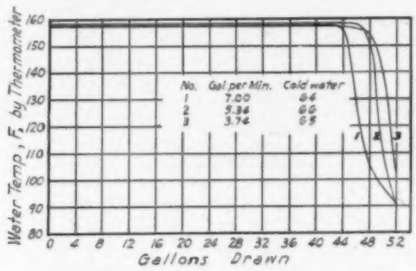

Fig. 1—Temperature of water delivered at various rates of continuous draw-off for a 52-gal tank

In Fig. 3 is given the time required to heat a 52-gal tank when equipped with two 1,000-watt heaters as compared to one 1,500-watt heater. The one 1,500-watt heater was installed near the bottom of the tank while on the two heater tank, one 1,000-watt heater was installed near the bottom and the other about one-fourth of the distance down from the top of the tank, affecting about 25 per cent of the capacity of the tank.

With the electric tank equipped with immersion heaters, the hot spots frequently found in other types of domestic water heating equipment are eliminated.

The temperatures recorded with one thermocouple located on the surface of the heating element and the other thermocouple located in the water, ¼ in. from the surface of the heating element are given in Fig. 4. No thermostats for control of temperatures were used in this test, therefore the test shows actual temperatures in transmitting heat to water with the immersion type heating element.

Being able to apply the heat directly to the water as with the electric immersion type heating element, it is possible to hold radiation losses or waste heat of the storage unit to the minimum. The majority of well-constructed factory-built immersion type electric storage water heaters will vary from 90 to 97 per cent efficiency in operation.

The action of the heating elements cutting on and off to maintain temperature within the tank is shown in Fig. 5. In this case, the temperature was set for 160 F and no water was drawn from the tank during this test. The numerals on the curve lines refer to the thermocouples attached to the tank. It is standard practice to use six thermocouples, No. 1 attached to the top of the tank and No. 6 attached to the bottom of the tank and the other four equally spaced along the sidewall of the tank. On standby and radiation loss tests, the difference in the readings of thermocouples Nos. 1, 2, 3, and 4 is so little that it is impractical to plot each thermocouple reading.

Indicated in Fig. 6 is the rate of temperature drop where a 52-gal tank has been heated to 160 F and left to cool in a room at 70 F. It is generally standard practice to compute these tests on the basis of a 70 F differential between water and room temperature.

Selection of Tank Storage Capacity

Little authentic data relative to the use of water in the average American home are available. Therefore, it has been necessary to use *rule of thumb* water consumption methods which have from time to time been corrected, until the present time when very few misapplications or incorrectly sized installations are made.

It has been the practice in the plumbing industry during the past few years to estimate that each individual used approximately 100 gal of water per day, and that of this amount, approximately 30 gal were hot water. Experiences over the last eight or nine years indicate that the average person uses much less than 30 gal of hot water per day.

Of course, it has not been possible to isolate the so-called *average* family, but in attempting to do so, it has been found in estimating hot water requirements that the family must be classified. Efforts along this line indicate that in the lower-priced homes, the use of water

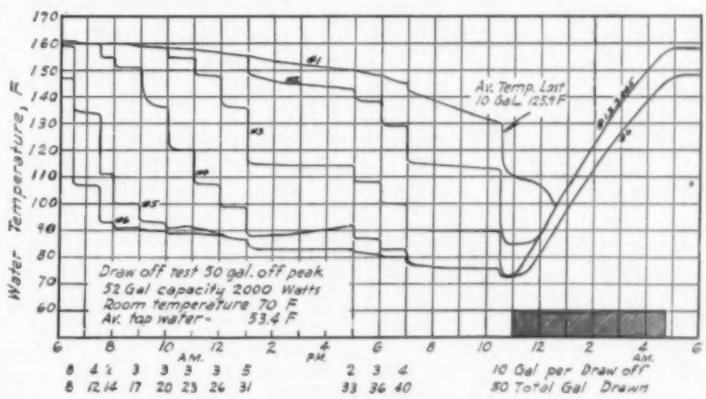
Water Temperature, F.
Av. Temp. Last 10 Gal. 125.9 F
Draw off test 50 gal. off peak
52 Gal capacity 2000 Watts
Room temperature 70 F
Av. tap water- 53.4 F
10 Gal per Draw off
50 Total Gal Drawn

Fig. 2—Effect of baffling the cold water supplied to a 52-gal tank, heated during the night

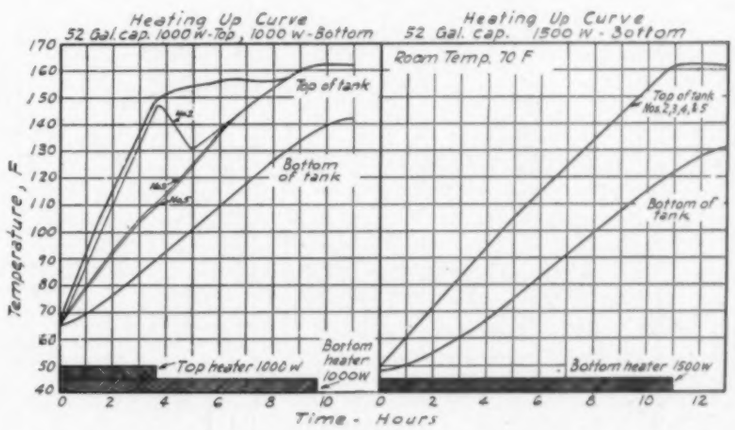

Fig. 3—Time required to heat 52-gal tank with two 1,000-watt heaters as compared with one 1,500-watt heater

will run from 7 to 10 gal per person, while in the medium-priced homes, the average will run from 10 to 15 gal per person, and in the larger, more pretentious homes, the use of hot water will vary from 20 to 30 gal per person.

During the past three or four years, values given in Table 1 have been found satisfactory in estimating the size of tank that should be installed to insure satisfactory hot water service.

Heating Element Wattage Requirements

To correctly specify the size of electric heating elements that should be installed, two factors should be considered; first, the amount of water to be heated and secondly, the number of hours during which electricity is available for heating water. Obviously, it is advisable to install the lowest wattage that will do the work satisfactorily, as by so doing, the heaters are in use more constantly throughout the hours of service and the utility enjoys a better load factor.

In estimating the wattage to be installed in the bottom heating element, it is customary to ignore the top heating element, as the top heating element is considered as an emergency unit. As 1 kwhr of electrical energy will raise the temperature of 4.1 gal of water 100 F, the standard practice is to divide the quantity of water to be heated by the number of hours in which it must be heated, thereby obtaining the number of gallons per hour that must be heated. This is particularly true in off-peak or controlled service water heating. In 24-hour water heating service, consideration must be given to the fact that approximately 60 per cent of the hot water used in the home is used during the morning hours of the day, and in all cases, it is advisable to have a full tank of hot water at the start of the day. Therefore on 24-hour service, the tank must be large enough to take care of the morning peak and have sufficient heater capacity to take care of the evening peak. On 24-hour service, there is usually little water used during the afternoon period. Therefore, the afternoon hours are available for building up storage for the evening peak. If sufficient wattage is installed in the heater to insure a full tank of hot water in the morning and the storage capacity of the tank is sufficient to take care of the morning peak, the same wattage heating element will insure satisfactory service over the evening peak.

The actual wattage of the heating element required to heat various sizes of tanks during various lengths of charging periods, based on 100 F temperature rise, is given in Table 2. A 15 per cent safety factor has been allowed in computing these heating element sizes; the 15 per cent being allowed to cover outages of electric service that might affect the time of heating.

Table 1—Sizes of Electrically Heated Hot Water Storage Tanks

Maximum Daily Requirement of 150 F Water in Gallons	Tank Capacity in Gallons[a]		
	24 Hour Heating Electric Service	Semi-off-peak Electric Service[b]	Full Off-peak Electric Service[c]
25	30	30	30
35	30	30	40
45	30	40	52
60	40	52	66
75	52	66	80
100	66	80	120
120	80	120	Two 66
150	80	Two 80	Two 80
175	120	Two 80	Two 120

[a]Tanks with two heating elements are recommended because in cases of excessive use of water on 24 hour electric service, quicker response is possible and on off-peak electric service reasonable quantities are made available shortly after the time clock closes the electric circuit.
[b]Lower unit off-peak; upper unit automatic during all 24 hours.
[c]With one or two units, depending upon charging period and wattage necessary.

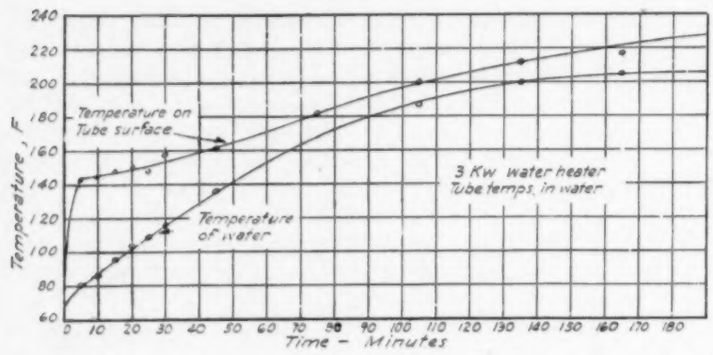

Fig. 4—Water and heating element temperatures recorded during a heating-up period

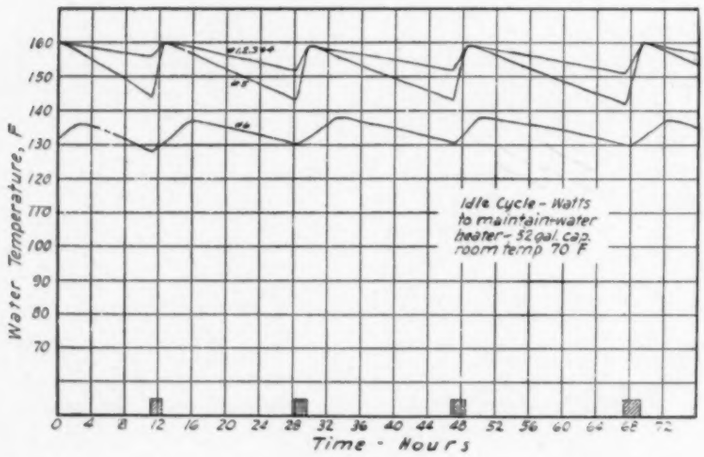

Fig. 5—Cutting on and off action of heating elements to maintain uniform tank temperature

Selection of Ferrous or Non-Ferrous Tanks

In all cases, information relative to the kind of water to be heated must be obtained if a satisfactory length of service may be expected from the equipment installed. Generally the water used in the homes of this country may be divided into two classifications, hard or alkaline water and soft or acid-reactive water.

The galvanized tank will give approximately 10 years of service on the average where alkaline water conditions are encountered. In many cases much longer life is obtained, although to be safe in estimating tank life, 10 years has been found a satisfactory value. Where soft or acid reactive water is encountered, non-ferrous metal tanks should be specified, as the life of a galvanized tank is short in proportion to the amount of acid contained in the water.

Usually the history of the water conditions may be obtained from the local authorities, but

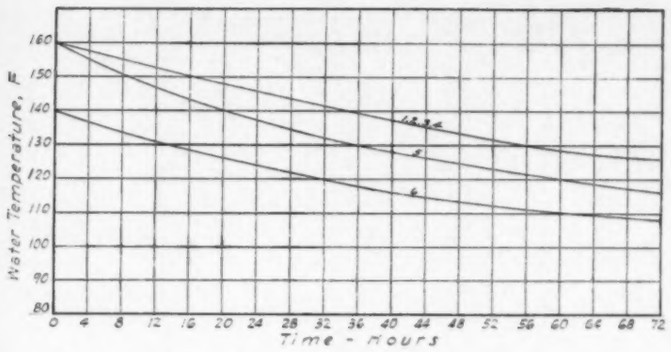

Fig. 6—Water cooling curves for 52-gal tank in a 70 F room

where such information is not available, it can be determined through a chemical analysis of the water. Where a chemical analysis is made, it is advisable to do so as promptly as possible after the samples are obtained in order to obtain a true analysis. Where there is considerable delay between the selection of the samples and the completing of the analysis, such destructive agents as free-oxygen may be lost and an incorrect analysis obtained.

Usually local authorities can give information as to the *pH* values of water and for all practical purposes, this value may be used to determine the kind of a tank to be installed. Readings of 7.0 *pH* and lower, usually indicate some acid condition, while *pH* readings above that figure, usually indicate an alkaline condition where galvanized tanks would be satisfactory. Many of the chemical companies have Block Comparator sets that may be used for determining the *pH* value of water.

If copper or copper base metals are used for tank construction, where chlorine is encountered, it should be made sure that the copper tanks are properly tinned, otherwise complaints of discolored water may develop.

Table 2—Sizes of Electric Water Heaters

Tank Size in Gallons Required from Table 1	Size Heater (Kw) Desirable[a] for Off-Peak Periods of						
	6 Hour	7 Hour	8 Hour	9 Hour	10 Hour	11 Hour	12 Hour
10	0.48	0.41	0.36	0.32	0.29	0.26	0.24
30	1.44	1.23	1.08	0.96	0.86	0.78	0.72
40	1.91	1.65	1.44	1.28	1.15	1.05	0.96
52	2.50	2.14	1.87	1.66	1.50	1.36	1.24
66	3.16	2.71	2.37	2.12	1.90	1.73	1.58
80	3.83	3.29	2.88	2.59	2.30	2.09	1.91
120	5.75	4.93	4.31	3.82	3.45	3.14	2.88

[a]Where required unit size is between two standard unit sizes, specify the larger size. Generally heaters are available in 500, 750, 1000, 1250, 1500, 1750, 2000, 2500, 3000, 3500, 4000 and 5000 watt sizes.

NOTE. For each 10 F below 50 F in the entering cold water, *add* 10 per cent to the wattage required.

For each 10 F above 50 F in the entering cold water, *deduct* 10 per cent from the wattage required. (This is on the basis of thermostats set for 150 F water temperature).

Proper Heater Location

In past years it has been the practice to locate the water heater as close as possible to the point where the water service main enters the building. Such installations have resulted in considerable waste of heat and with higher operating cost than is necessary. It is recommended therefore that where possible, the heater be located as close as possible to the point of the greatest use of hot water. In the home, this is usually the kitchen, therefore the water heater should be installed directly below the kitchen in order to avoid long runs of pipe in which the water may cool between draw offs and unnecessarily increase the operating cost.

Where the electric water heater is to be used in conjunction with some other type of heater, it is advisable to use a series hookup similar to that arrangement shown in Fig. 7.

If the electric heater was connected directly to the furnace coil, there is a possibility of water being delivered from the furnace coil in mild weather at a temperature that is not satisfactory, and still that temperature might be just high enough to keep the thermostat of the electric water heater from closing the circuit to the electric heater and unsatisfactory temperature water would result. By using a tempering tank between the furnace coil and the electric heater, this condition may be avoided to a large extent. At the same time, the uninsulated tank will act as a tempering tank throughout the summer months and will effect a saving in the use of electricity for water heating by absorbing temperature from the basement and thereby raising the temperature of the water above the temperature at which it enters from the city mains.

In larger homes, it may be possible to use more than one water heater to advantage by eliminating long pipe runs with their additional piping expense, and additional heat losses. The electric unit lends itself ideally to these situations, because the electric water heater may be installed without considering such factors as flue connections and other combustion problems.

Where the quantities of hot water required are in excess of the storage capacity of standard units, it is possible to connect two tanks of equal size in parallel. In doing so, care should be taken to make sure that there is a balanced flow of water through both the tanks. In other words, to make sure that there is no more friction in the flow through one tank than through the

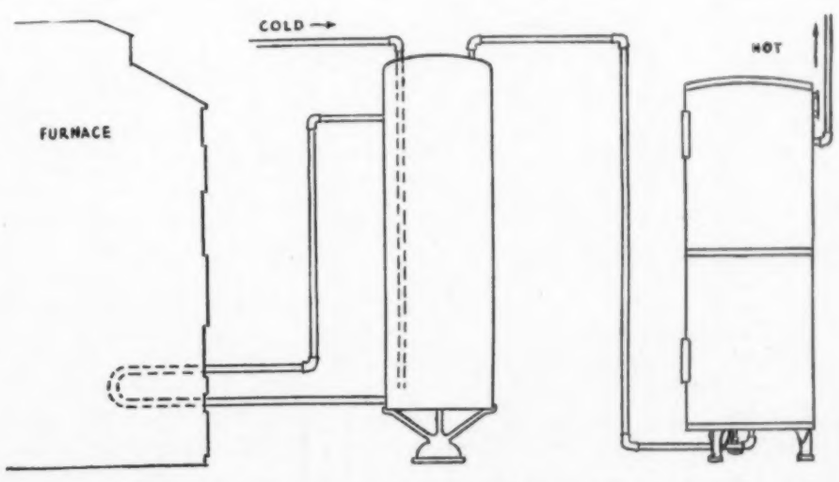

Fig. 7—Series piping connection for multiple tank installation

other. If an unbalanced situation does arise, unsatisfactory service will result, due to one tank doing the major portion of the work. The correct means of connecting two electric storage units in parallel is illustrated in Fig. 8. The piping arrangement for a tempering tank connected to an electric water heater is shown in Fig. 9. Information on the mixture of hot and cold waters is given in Tables 3 and 4.

Estimating Operating Costs

From various data collected it is indicated that 300 kwhr per month is a national average for domestic hot water service, electrically heated. This is a national average, and of course due to the warmer tap water temperatures in the South and the colder tap water temperatures in the North, this national average value must be weighed accordingly. From data available, it appears that the Southern average is approximately 200 kwhr per month per customer, while the Northern average is about 425 kwhr per month per customer.

In estimating operating costs, the approximate amount of hot water that will be required must first be determined. For storage type water heaters 150 F has been accepted as a standard thermostat setting. Basing the temperature rise on 100 degrees the total amount of water may be divided by 4.1 and arrive at the total number of kilowatt hours used for heating the water in the tank. To this value should be added from 15 to 25 per cent depending upon the piping layout to determine the overall kilowatt hour consumption. Then by multiplying the kilowatt hours by the prevailing electric rate, a reasonably close estimate of the operating costs may be obtained.

One other *rule of thumb* method is to divide the total number of gallons of hot water required by 3.5 to get the total kilowatt hours required, then multiplying this value by the prevailing rate for water heating service.

Most electric storage type water heaters, provided with the heating elements immersed within the tank, are well insulated and for all practical purposes, may be assumed to be almost 100 per cent efficient in calculating both rate of heating and estimating of operating costs. Allowance must be made, however, for the losses from the piping as previously suggested.

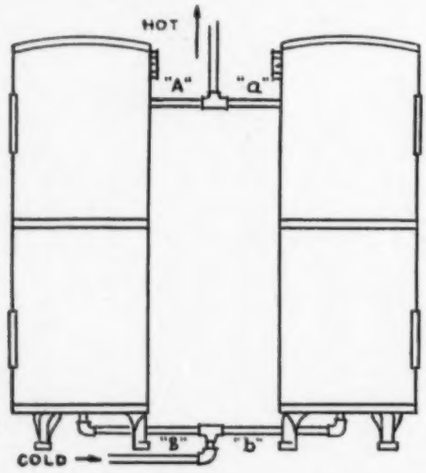

Fig. 8—Correct piping connection for two tanks arranged in parallel[a]

[a]Pipes *A*, *a* and *B*, *b* must be the same length to insure a balanced flow from each heater.

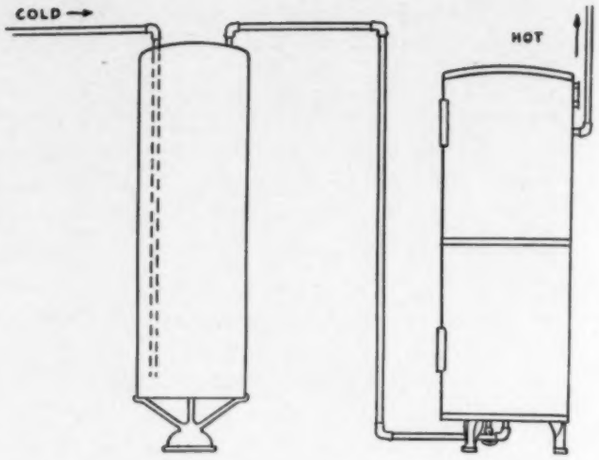

Fig. 9—Tempering tank connection with electrically heated tank

The use of copper tubing for electric storage water heating connections is growing in popularity, due principally to the fact that smaller sizes of copper tubing may be used than is possible with galvanized pipe, and as a result, pipe radiation losses and losses due to water cooling within the pipe are considerably reduced.

Table 3—Amounts of Hot Water Required in 10 Gal Mixtures[a]

Mixture Desired at F Temperature	Amount of 150 F Hot Water Required in Gallons
100	5.0
105	5.5
110	6.0
120	7.0
130	8.0
140	9.0

[a]Based on 150 F tank temperature; and 50 F cold water.

Table 4—Amounts of 100 F and 120 F Water Obtainable From Various Quantities of 150 F Water[a]

150 F Water	Gallons of Mixed Water at	
	120 F	100 F
30 Gal	45 Gal	67.5 Gal
50 Gal	75 Gal	112.5 Gal
66 Gal	99 Gal	148.5 Gal
80 Gal	120 Gal	180.0 Gal
120 Gal	180 Gal	270.0 Gal

[a]Based on 150 F tank temperature; and 60 F cold water.

Statistics on Air Conditioning Orders

Statistics for the month of August on the value of orders booked for air conditioning systems and equipment have been released by the Bureau of Census, Department of Commerce, Washington, D. C. A survey of the figures included in this report indicates that from 98 manufacturers in this particular field that during the first eight months of this year, from January to August, a total of $28,156,456 have been booked and recorded from information supplied by the various individual manufacturers.

Hygro-Xylometric Control of Air Conditioning

By **H. H. Tunis** (*NON-MEMBER*)

AIR conditioning may be defined as controlling the temperature and moisture content of room atmosphere in accordance with a given specification.

When we speak of the variations of temperature and humidity of the air, however, we find several factors which are so interrelated that proper comprehension of the theory requires that they should be understood to some degree. The third factor, which might be considered as the third leg of a triangle, is pressure—barometric and vapor.

The humidity of the air is best expressed in grains of moisture per pound of air, since these two weights do not vary with either temperature or pressure. The maximum weight of moisture which can be absorbed by a given weight of air is known as the dew or saturation point, and this amount increases with the temperature. This is termed absolute humidity. For example, it requires twice the weight of water to saturate a pound of air at 80 F as it does at 60 F. The percentage of this saturation, at a given temperature, is known as the relative humidity, which is the value mostly given in psychrometric readings.

For certain purposes, the absolute humidity is expressed in grains of moisture per cubic foot of air. This is a desirable factor when the capacity of rooms is considered, at a uniform temperature; but, as before stated, it varies with temperature, as does also relative humidity. Thirteen cubic feet of air weighs one pound at 60 F, but it requires 14 cu ft at 95 F—a variation of about 0.25 per cent per degree change.

The evaporation of moisture from a surface is greater as the humidity of the air increases, and ceases entirely at the dew point (100 per cent relative humidity). This evaporation tends to cool the moist surface, and, in the case of the wet bulb thermometer, the amount of such cooling is an index of the humidity in air at the temperature indicated by the dry bulb thermometer.

Having these two temperature (or psychrometric) readings, we can determine either the relative or absolute humidity by reference to a psychrometric chart which shows the curves of each factor. The relations are also shown on the accompanying chart, Fig. 1, of hygro-xylometric conditions of air.

Study of such a chart will show certain relationships which may be helpful in comprehending atmospheric laws.

At uniform relative humidity, increased temperature, either wet or dry bulb, indicates an increased absolute humidity.

At uniform absolute humidity, reduced relative humidity indicates an increase in temperature.

At uniform relative humidity, the difference between wet and dry bulb temperature increases slightly as temperature increases.

At uniform absolute humidity, the difference between wet and dry bulb temperature increases almost as rapidly as the temperature increases.

Observations of the variations in block thickness, at different air conditions, as indicated by the hygro-xylometer, have been plotted on the accompanying chart, so that the air conditions which will cause no change in block thickness can be determined.

Two hygro-xylometers have been in use since February, 1933—over three years. We have endeavored to correct the errors which the gradual drying out of the blocks might cause, but as yet have found that they seem as sensitive as when first installed. The uniform condition of rooms should keep them from losing the desired elasticity for a longer time than if subjected to the varying humidities of outdoor conditions. The adjustment of these instruments, which is done during

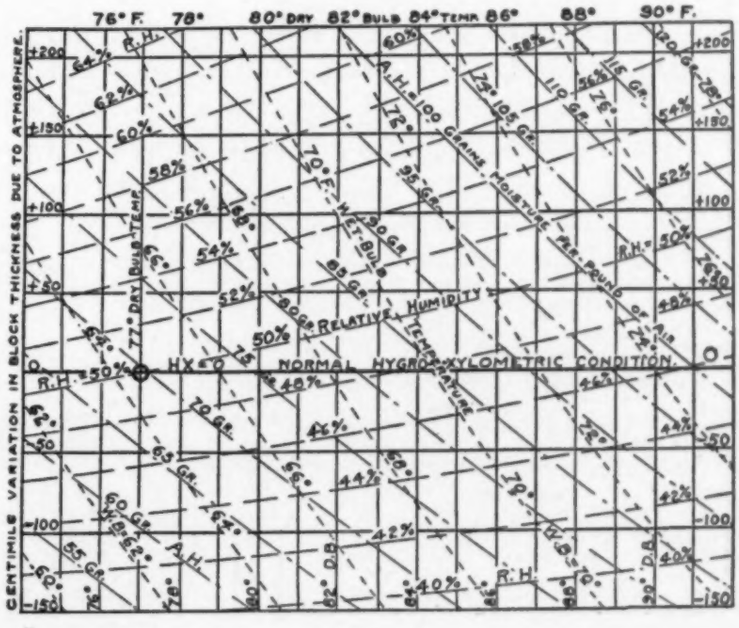

Fig. 1—Hygro-xylometric conditions of air

the winter season, is made so that the average *HX* reading is zero when a temperature of 77 F and relative humidity of 50 per cent prevails.

As the species of cherry wood used and the direction of the grain may cause over 50 per cent difference in the *shrinkage* factor of a mounting block, the hygro-xylometric variations—or those due to the moisture content and heat of the wood—can be approximated within close limits, for a specific block, but not for cherry wood, in general. We can, however, determine a point ($HX = 0$) at which all wood will have the same *shrinkage* when returned to that condition. To maintain this reading is the aim of hygro-xylometric control.

In the aero-xylometer, a layer of wood, the thickness of paper, is cemented to a very thin strip of brass which when coiled into clock spring shape operates the index hand on the dial. In this case, even though edge-grain instead of end wood, is presented to the air, the relative time for effective action is less than 1/100 of the time required for equivalent movement of the block. On the basis that the rate of drying out is proportionate to the rate of moisture adsorption, the veneer strip now in use on the clock spring instruments is as dry as the block will be in about 300 years, yet no appreciable change in the action of the *spring* has been observed.

In the block type instrument, calibration of the dial movement was made directly by micrometer, while that of the spiral type by plotting a curve of the comparative readings of the two types of instruments.

The aero-xylometer gives the *HX* condition of the air at the time of reading, while the hygro-xylometer, kept in the same atmosphere, will not reach that reading within 12 hours. By correcting the air condition to $HX = 0$, the variation from normal of the mounting blocks in storage can be checked.

The hygro-xylometer is the index of the type-height of cuts in galley storage, but there again the *time lag* plays on the safe side. The mounted cut, in type matter, is so surrounded with metal that moisture change is much slower than in the block element of the hygro-xylometer. For this reason, it would take about a week of abnormal atmosphere for the cuts stored in galleys to change the amount indicated by the instrument.

It is interesting to note that between the limits of 70 F and 81 F the normal *HX* is also within the comfort zone as determined by the AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

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Research Needed Now

There are innumerable problems for which Research must provide the correct answers. The A. S. H. V. E. Committee on Research is besieged with requests for more intensive work in the heating, ventilating and air conditioning fields.

Problems are being assigned as rapidly as funds permit and now 12 investigations are under way, several at the Research Laboratory at the Bureau of Mines in Pittsburgh, and in the following cooperating institutions: University of Minnesota, Marquette University, University of Illinois, University of Illinois Medical College, Harvard School of Public Health, Michigan College of Mining and Technology, Case School of Applied Science, A. & M. College of Texas, Carnegie Institute of Technology, and University of Wisconsin.

An estimate made by the Research Finance Committee indicates that in 1936-37 $100,000 should be expended on investigations to supply fundamental data needed by the profession.

The Society's TRANSACTIONS are filled with the reports made on studies conducted under the supervision of the Committee on Research since 1919. The complete bibliography makes a very imposing list of references on a great variety of subjects. Much of the data have been condensed and published in THE A. S. H. V. E. GUIDE—other data have formed the basis for the Standard Codes of the Society.

The work of the Society has been widely and profitably applied by members of the profession and those engaged in the allied industries so that the Committee on Research invites their whole-hearted cooperation and support in carrying on essential studies for the development of the art of heating, ventilating and air conditioning.

NOMINATIONS FOR 1937

The Nominating Committee appointed to select candidates for Officers of the Society for the coming year, 1937, submits the following list of nominees:

For President:

D. S. BOYDEN, Boston, Mass.

For First Vice-President:

E. H. GURNEY, Toronto, Ont., Can.

For Second Vice-President:

J. F. MCINTIRE, Detroit, Mich.

For Treasurer:

A. J. OFFNER, New York, N. Y.

For Members of the Council:

Three-Year Term

J. J. AEBERLY, Chicago, Ill.
M. C. BEMAN, Buffalo, N. Y.
E. O. EASTWOOD, Seattle, Wash.
W. A. RUSSELL, Kansas City, Mo.

Respectfully submitted,

NOMINATING COMMITEE,

J. H. VAN ALSBURG, *Acting Chairman;*
R. J. TENKONOHY, *Secretary.*

In accordance with the provisions of the Amended Constitution, as given, ballots containing the names of the above candidates will soon be sent to the membership for voting upon prior to the Annual Meeting in January.

Art. B-VIII—Section 10. The Nominating Committee shall consist of one (1) member eligible to vote designated by each Chapter, or his alternate also appointed by the Chapter. The Secretary of each Chapter shall certify to the Secretary of the Society on or before January first the names of the member and alternate selected.

The Committee shall meet at the Annual Meeting of the Society at the call of the Secretary of the Society and shall effect its own organization and elect its own Chairman. At the Semi-Annual Meeting of the Society, if possible, the Nominating Committee shall select the nominees for the ensuing year for the offices of President, First Vice-President, Second Vice-President, Treasurer, and four (4) members of the Council. In any event the names of the nominees shall be certified to the Secretary of the Society before September twentieth, with the written consent of each nominee to fill the office for which he has been selected and their names with the offices to which they have been nominated shall be published in the October issue of the JOURNAL.

Art. B-IX—Section 2. The Secretary shall prepare ballots with the names of all candidates and forward them to the members, eligible to vote, at least thirty (30) days before the date of the Annual Meeting.

Nominations for Members of Committee on Research

Although committees of the Society are usually appointed, in view of the great importance of the Committee on Research and the financial responsibility it would be called upon to assume, it has been made more representative of the entire membership of the Society by a process of *election*. The election is governed by the By-Laws for the election of officers, with the single exception that Members of the Committee on Research are nominated by the Council instead of by a Nominating Committee.

In accordance with the Regulations for the Government of the Research Laboratory, adopted at the January, 1919, Meeting, and amended January, 1933, the Council announces the nomination of the following members of the Committee for election to succeed those members whose present terms expire January, 1937:

Three-Year Term

H. E. ADAMS, South Norwalk, Conn.
A. E. STACEY, New York, N. Y.
G. L. TUVE, Cleveland, Ohio.
J. H. VAN ALSBURG, Chicago, Ill.
J. H. WALKER, Detroit, Mich.

The regulations governing the nomination and election of members of the Committee on Research are as follows:

ARTICLE II—ORGANIZATION

Section 1. *Committee on Research*—There shall be a standing committee known as the Committee on Research, consisting of fifteen (15) members each serving for three (3) years and five (5) retiring each year. The outgoing Chairman if serving in that capacity during the last year of his three (3) year term on the Committee shall without election become an additional member of the Committee on Research for one (1) year.

(*a*) The Council shall nominate previous to July first of each year five (5) members to fill the vacancies of those retiring at the next Annual Meeting.

(*b*) The nominations made by the Council shall be published in the October issue of the Society's JOURNAL.

(*c*) Any ten (10) members of the Society eligible to vote may present to the Secretary over their signatures, the name of one (1) or more additional nominees for the Committee on Research, provided such name or names are presented at least sixty (60) days prior to the next Annual Meeting, and such additional nominations shall be placed on the ballot opposite the nominations made by the Council.

(*d*) The election shall otherwise conform to the regulations provided for the election of officers of the Society in the Constitution, By-Laws and Rules.

(*e*) Vacancies may be filled by the Council, such persons chosen by the Council to serve until a successor is elected at the next Annual Meeting.

Statue of St. Louis

Society Meets in St. Louis

Hotel Statler

ST. LOUIS will be the scene of the Society's 43rd Annual Meeting and the members of the local chapter will be hosts for the occasion. The Committee on Arrangements promises an outstanding meeting and invites every member of the Society to visit St. Louis, Mo., on January 25-27, 1937. St. Louis is an important gateway city and offers much to the visitor in beautiful buildings, broad boulevards, fine churches, schools, universities, the park system, harbor and levees of the Mississippi, mammoth bridges and many historical buildings.

Meeting headquarters will be at Hotel Statler in the downtown shopping district close to the department stores and theaters.

On a tour of the city the visitor will see a statue of St. Louis which marks the landing place of its founder, and among other historical places are the old cathedral, courthouse, slave market, old rock house, all commemorating the days of the early settlers.

In the newer St. Louis will be found the Soldier's Memorial Plaza, Civic Auditorium, Courthouse, Federal Building, Jefferson Memorial which houses the Lindbergh trophy exhibit, museum, Municipal Theater, Zoological Gardens. Among other points of interest are Forest Park, Shaws Garden, Washington University, St. Louis University and the Anheuser-Busch Brewery.

St. Louis is an important railway center and is readily accessible from all points of the United States. It enjoys excellent air service and is served by national highways from all points of the compass so that members can travel by train, airplane or by automobile.

The Program Committee has set aside Monday morning for Registration, Committee meetings and a Conference of Chapter Representatives. Technical sessions will commence at 2 p. m. Monday afternoon with Pres. G. L. Larson presiding. Some of the topics to be discussed at the Technical Session are: Conductivity of Concrete, Duct Design, Selection of Air Outlets, Noise Elimination in Ventilation Systems, Fan Characteristics, Cooling Rates of Radiators, Summer Comfort Requirements, Oil Burning Research, Stoker Performance, Air Removal in Vacuum Systems.

The Committee in charge of arrangements is: C. R. Davis, *General Chairman;* L. W. Moon, *Vice-Chairman;* R. J. Tenkonohy, *Reception;* P. W. Sodemann, *Transportation;* D. J. Fagin, *Entertainment;* G. W. F. Myers, *Banquet;* J. W. Cooper, *Ladies;* E. E. Carlson, *Publicity;* C. E. Hartwein, *Finance.*

Memorial Plaza

L. T. Avery, *President*

Philip Cohen, *Secretary*

Cleveland

The Cleveland Chapter opened the 1936-37 season Tuesday evening, October 20, at the Cleveland Club when the subject of Air Conditioning Standards for the Cleveland Area was discussed under the leadership of H. E. Wetzell. Pres. G. L. Larson of the A.S.H.V.E., Madison, Wis., will be the guest speaker at the November 11 meeting and will talk on The Economics of Good Construction as Related to Residence Heating. Plans for the December meeting are now being formulated.

The Chapter has 31 A.S.H.V.E. members and activities are directed by the following officers and standing committees:

President—L. T. Avery.
Vice-President—F. R. Dickenson.
Secretary—Philip Cohen.
Treasurer—H. M. Nobis.
Board of Governors—G. L. Tuve, W. D. Graham, H. E. Wetzell.
Membership Committee—R. A. Wilson, *Chairman*, E. W. Gray, E. B. Carey, W. M. Rowe, G. L. Tuve, J. G. Harris.
Program Committee—F. R. Dickenson, *Chairman*, F. A. Rodgers, W. R. Beach.
Meetings & Entertainment Committee—M. F. Rather, *Chairman*, A. L. Vanderhoof, W. M. Rowe.
Standards Committee—H. E. Wetzell, *Chairman*, E. B. Carey, W. D. Graham, C. A. McKeeman.
Auditing Committee—C. F. Eveleth, *Chairman*, G. B. Longcoy.
Constitution Revision Committee—F. A. Kitchen, *Chairman*, M. F. Rather, C. F. Eveleth.
Publications Committee—J. A. Schurman, *Chairman*, L. C. Minnie.
Legislation Committee—F. A. Kitchen, *Chairman*, L. O. Weldy.

Secy. Philip Cohen has presented a synopsis of activities during the past season.

October, 1935. Speaker: John Howatt, president of the A.S.H.V.E. Subject: Standards for Air Conditioning. Attendance: 125 members and guests.

November, 1935. Speakers: W. G. Frank, assistant chief engineer, American Air Filter Co., Inc.; J. A. Schurman, sales engineer, York Ice Machinery Co., and Philip Cohen, district manager of the B. F. Sturtevant Co., Cleveland. Subject: Air Cleaning Methods and Devices (Illustrated). Attendance: 75 members and guests.

December, 1935. Speakers: E. L. Anderson, director of research of the American Blower Corp., Detroit, E. B. Carey, consulting engineer, Cleveland, and L. T. Avery, Avery Engineering Co. Subject: Sound Detection and Measurements in Air Handling Equipment (Illustrated). Attendance: 90 members and guests.

January, 1936. Speaker: Dr. C. A. Mills, professor of experimental medicine, University of Cincinnati. Subject: The Physiological Aspects of Air Conditioning (Illustrated). Attendance: 400 members and guests.

February, 1936. This meeting was sponsored by the Cleveland Chapter Entertainment Committee. Subject: Valentines—Light and Dark; Why Coils—Pipes—Tubes—Orifices? Attendance: 50 members and guests.

March, 1936. Speaker: F. C. Houghten, director of A.S.H.V.E. Research Laboratory, Pittsburgh, Pa. Subject: Comfort Standards for Summer Air Conditioning (Illustrated). Attendance: 75 members and guests.

April, 1936. Speakers: C. A. Thompson, residential building contractor, E. P. Farris, managing director, Central Bureau for Heating and Air Conditioning, C. E. Hansen, engineer, Smith & Oby Co., Cleveland, and F. R. Dickenson, district manager, American Blower Corp., Cleveland. Subject: Residential Air Conditioning. Attendance: 100 members and guests.

May, 1936. Speakers: B. C. Wright, Bryant Heater Co., and W. R. Rhoton, W. R. Rhoton Co., Cleveland. Subject: Methods of Air Conditioning, (1) Direct Dehumidification (2) Evaporative Cooling. Attendance: 100 members and guests.

June, 1936. Speaker: Walter Sturrock, illuminating engineer, General Electric Co., Cleveland. Subject: Heating Effect of Artificial Lighting (Illustrated). Attendance: 50 members and guests.

E. B. Royer, *President*

K. W. Schick, *Secretary*

Cincinnati

Activities of Cincinnati Chapter are in charge of the following Officers and Board of Governors:

President—E. B. Royer.
Vice-President—I. B. Helburn.
Secretary-Treasurer—K. W. Schick.
Board of Governors—I. B. Helburn, G. B. Houliston, W. C. Pistler, E. B. Royer, K. W. Schick.

An outline of meetings held during the season of 1935-36 is included in the annual report of the Chapter.

September 19, 1935. Luncheon meeting at the Hotel Gibson. Attendance—17. Subject—Participation in Cincinnati formative group to be known as Technical Societies Council of Cincinnati.

September 30, 1935. Attendance—7. Subject—Discussion of Chapter business.

October 29, 1935. Dinner meeting at Times Tavern. Attendance—16. Subject—Approval of action of Sept. 30 meeting and discussion of membership and meetings.

November 19, 1935. Dinner and meeting at Engineers Club, Dayton, Ohio. Attendance—125. Pres. John Howatt of the A.S.H.V.E., Chicago, Ill., was guest of honor. Speaker—M. J. Stevenson. Subject—Design of Air Conditioning Installations to Meet Variable Outdoor Atmospheric Conditions in Summer.

December 10, 1935. Evening meeting at Engineers' Club. Attendance—11. Subject—Discussion of paper, Comfort Standards for Summer Air Conditioning, led by L. G. Powers.

December 28, 1935. Annual Christmas stag party and luncheon at Hotel Gibson. Attendance—22.

January 14, 1936. Annual social meeting and dinner at Hotel Gibson, with dinner dance and social evening. Attendance—33.

February 6, 1936. Joint meeting of *Cincinnati Technical and Scientific Societies* in the Music Hall Auditorium. Attendance—3000. Speaker—Capt. A. W. Stevens, U. S. Army Air Corp., commander of stratosphere balloon Explorer II. Subject—Man's Farthest Aloft.

March 10, 1936. Dinner and meeting at Hotel Gibson. Attendance—14. Business—Committee reports and chapter affairs.

April 15, 1936. Meeting in the auditorium of the Gas and Electric Co. Attendance—26. Speaker—Dr. C. A. Mills, University of Cincinnati. Subject—The Human Background of Air Conditioning.

May 12, 1936. Dinner and annual business meeting at Hotel Gibson. Attendance—18. Subject—Chapter affairs and election of officers.

N. D. Adams, *President*

J. E. Swenson, *Secretary*

Minnesota

Secy. J. E. Swenson has prepared the annual report of Minnesota Chapter and announcement has been made of the first three meetings of the 1936-37 season: *October* 12—Automatic Firing of Solid Fuels by Tom Marsh; *November* 5—Annual Fall Party; and *December* 14—Combustion Controls by Mr. Goetzenberger.

The following are the officers and committee chairmen serving Minnesota Chapter:

President—N. D. Adams.
Vice-President—R. E. Backstrom.
Secretary-Treasurer—J. E. Swenson.
Board of Governors—G. C. Morgan, R. C. Jordan.
Meetings Committee—R. E. Backstrom, *Chairman.*
Legislative Committee—F. B. Rowley, *Chairman.*
Publicity Committee—R. C. Jordan, *Chairman.*
Nominating Committee—C. E. Gausman, *Chairman.*
Auditing Committee—G. C. Morgan, *Chairman.*
Entertainment Committee—M. H. Bjerken, *Chairman.*
Membership Committee—G. B. Gerrish, *Chairman,* H. M. Betts, *Vice-Chairman.*
Finance Committee—D. M. Forfar, *Chairman.*

Minnesota Chapter numbers 133 members on its roll and a synopsis of meetings held during the past season is given:

September 17, 1935. Possibilities of Air Conditioning by R. E. Saberson. Members and guests attending—40.

October 14, 1935. Temperature Control by A. C. Grant, and Humidity and Its Controls by Mr. Lott. Members and guests attending—76.

November 11, 1935. Fall party.

December 16, 1935. Discussion of paper, Comfort Standards for Summer Air Conditioning, presented by Prof. A. B. Algren. Members and guests attending—38.

January 13, 1936. The Gas Industry's Contribution to Air Conditioning by W. E. Stark. Members and guests attending—90.

February 10, 1936. Air Distribution in Rooms by Mr. McCormick. Members and guests attending—35.

March 9, 1936. The Dust Problem in Air Conditioning by Prof. F. B. Rowley. Members and guests attending—38.

April 13, 1936. Twin City Sewage Disposal System by Prof. Frederick Bass. Members and guests attending—42.

May 5, 1936. Election of officers.

Pittsburgh Chapter Enjoys Inspection Trip

October 12, 1936. No formal business meeting of Pittsburgh Chapter was held in October because of the nature of the program.

A small group of the members met for dinner at McCanns Restaurant. Following dinner, Pres. R. J. J. Tennant outlined the program proposed for the November meeting and appointed the following nominating committee to report at the November meeting: L. B. Pittock, *Chairman,* C. M. Humphreys, P. A. Edwards.

The group then adjourned to the Stanwix plant of the Allegheny County Steam Heating Co. where several more joined the party. W. W. Stevenson conducted the group through the plant which included the system operators' office and instrument board, the meter testing room, the powdered coal fired boilers with a total capacity of 600,000 lb of steam per hour, and the 6,000 kva turbo generator which is used as a pressure reducing valve. The fifteen members and guests present greatly enjoyed the trip.

G. E. Olsen, *President*

T. W. Reynolds, *Secretary*

New York

A synopsis of meetings held from October, 1935, to May, 1936, has been included in the annual report of New York Chapter, which states that the average attendance at meetings during the past season was 93 and that the Chapter has a membership status of 159 members as of September, 1936.

The following members were elected to office for 1936-37:

President—G. E. Olsen.
Vice-President—W. E. Heibel.
Secretary—T. W. Reynolds.
Treasurer—W. M. Heebner.
Board of Governors—D. J. Purinton, W. W. Timmis, H. G. Meinke.
Membership Committee—H. G. Meinke, *Chairman.*

October 21, 1935. Physiological and Medical Aspects of Air Conditioning was the subject of the first meeting of the 1935-1936 season when Dr. C. A. Mills, professor of Experimental Medicine, University of Cincinnati, was the speaker. Dr. Mills gave an interesting address on the physiological and beneficial effects of air conditioning on the human being based on research which he has done in numerous countries on the effect of various climates on various races. A record attendance of 219 was obtained.

November 18, 1935. Generation of Power was the subject of the November meeting. The speaker, J. C. Falkner, assistant chief operating engineer, New York Edison Co., Inc., gave a detailed account of the progress of energy through a generating station from the coal pile to the outgoing feeders.

Reginald Pelham Bolton, consulting engineer and past president of the A.S.H.V.E., then gave an informal talk on the Development of Engineering in New York City. This was given in his usual reminiscent, humorous and wholly delightful manner.

December 16, 1935. The December meeting was a social event in which bridge and other games were featured. Attendance—143.

January 20, 1936. The January meeting was given over to the reports of committees and the discussion of members on the proposed revision of Chapter 10, Code of Ordinances, City of New York. Members were interested as certain of the revisions vitally affect the design and installation of ventilating and air conditioning equipment.

February 17, 1936. Tests on Large Orifice Heating Systems With Various Types of Controls was the topic presented by Kirby Walker and W. H. Mertens. Prevention of Domestic Water Pollution from Heating and Air Conditioning Equipment and from Waste Water was the next subject, by Louis Northon.

March 16, 1936. C. R. Hiers, Minneapolis-Honeywell Regulator Co., and R. P. Dewey, Barber-Colman Co., spoke on New Developments in Automatic Controls. A visomatic or sound machine with slides was employed to review the important developments which have taken place in this field within the past two years.

April 20, 1936. Discussion and action was taken at the April meeting on the proposed code of minimum requirements for air conditioning. Col. W. A. Danielson, Washington, D. C., chairman of the Society's Committee on Research, addressed the meeting on the proposed research program of the A.S.H.V.E.

May 18, 1936. The annual dinner and entertainment under the direction of G. E. Olsen and his committee took place at the Building Trades Club. This was a most successful event and brought out an attendance of 332, which held until midnight.

C. R. Davis, *President*

R. J. Tenkonohy, *Secretary*

St. Louis

The St. Louis Chapter held its first meeting of the 1936-37 season on October 13, when C. E. Pullum, Bell & Gossett Co., Chicago, spoke on the subject of the One Pipe Water System Applied to Heating and Cooling.

Secy. R. J. Tenkonohy has reported that the Chapter now has 34 members on its rolls and the following officers and committees are in charge of activities:

President—C. R. Davis.
1st Vice-President—G. W. F. Myers.
2nd Vice-President—E. E. Carlson.
Secretary—R. J. Tenkonohy.
Treasurer—C. E. Hartwein.
Board of Governors—J. W. Cooper, D. J. Fagin, G. B. Rodenheiser, L. R. Szombathy, and the officers.
Program Committee—D. J. Fagin, *Chairman*, F. C. Laufketter, H. W. McLarney.
Membership Committee—G. W. F. Myers, *Chairman*, J. W. Cooper, Paul Sodemann.
Entertainment Committee—L. R. Szombathy, *Chairman*, E. E. Carlson, W. N. O'Brien.
Educational Committee—G. B. Rodenheiser, *Chairman*, C. F. Boester, J. M. Foster.
Publicity Committee—F. B. Fillo, *Chairman*, H. A. Grossmann.
Associated Engineering Societies—C. R. Davis, *Chairman*, Paul Sodemann, *Alternate;* J. D. Falvey, W. C. Sodemann, *Counsellors.*
Auditing—L. W. Moon, *Chairman*, R. M. Rosebrough, E. A. White.

A synopsis of meetings held during the past season is included.

Jan. 7, 1936. Speaker—M. M. Easley. Subject—Sound Control and Its Relation to Air Conditioning. Attendance—11 Members, 12 Guests.

Feb. 11, 1936. Speaker—F. I. Raymond. Subject—Primary Zone Control and Common Faults in Steam Circulation. Attendance—17 Members, 14 Guests.

Mar. 6, 1936. Speaker—J. C. Patterson. Subject—Silica Gel and Its Application to Air Conditioning. Attendance—17 Members, 24 Guests.

Apr. 1, 1936. Speaker—Prof. G. L. Larson, president of the A.S.H.V.E. Subject—The Economics of Good Construction as Related to Residence Heating. Attendance—14 Members, 19 Guests.

May 12, 1936. Speaker—S. Konzo. Subject—Residence Heating and Cooling. Attendance—21 Members, 51 Guests.

June 13, 1936. Social Party at Norwood Hills Country Club. Total Attendance—96.

Sept. 8, 1936. Speaker—F. R. Bichowsky. Subject—Industrial Drying with Lithium Chloride and Its Application to Air Conditioning. Attendance—12 Members, 21 Guests.

Oklahoma Chapter Opens Season's Activities

October 12, 1936. The first fall meeting of Oklahoma City Chapter was held in the electric bungalow of the Oklahoma Gas and Electric Co., and was called to order at 8:05 p. m. by Pres. F. X. Loeffler. There were 28 members and guests present.

On the suggestion of President Loeffler, Secy. E. W. Gray was elected to serve also as treasurer to fill the unexpired term of E. L. Beard.

President Loeffler urged membership in the Chapter, reading a list of those in good standing and suggesting the affiliation of others who are interested in local activities. President Loeffler also announced that at the December meeting air conditioning standards for Oklahoma would be discussed and he urged members to prepare definite suggestions and recommendations.

W. A. Russell, Kansas City, Mo., chairman of the Society's Membership Committee, was introduced and discussed the value of membership in the A.S.H.V.E.

Prof. F. E. Giesecke, director of the Engineering Experiment Station, Agricultural and Mechanical College of Texas, College Station, Tex., was presented and gave an interesting paper covering the history and principles of air conditioning, as well as a discussion of some of the research being carried on to further clarify effective temperatures producing optimum comfort.

Following presentation of the paper, upon request of one of the Chapter members Professor Giesecke gave a talk on hot water heating systems and a general discussion followed.

Leo Hungerford, *President*

H. M. Hendrickson, *Secretary*

Southern California

Plans are under way for the remainder of 1936 and the first meeting of Southern California Chapter was held on the second Tuesday in October. Southern California Chapter has spent considerable time and effort in the formulation of an Air Conditioning Code for the local territory and during the next few months plans to present the code to the industry and public.

A number of interesting and educational meetings were enjoyed during the past season. Secy. H. M. Hendrickson reports that the interest of the membership has been gratifying to the officers in charge and a good turn-out was recorded at every meeting. All of the meetings were held at the Rosslyn Hotel, Los Angeles, and the Chapter has 34 members and 20 affiliates on its roll.

The officers and chairmen of committees who will serve until the election in the spring are:

President—Leo Hungerford.
Vice-President—A. H. Simonds.
Secretary—H. M. Hendrickson.
Treasurer—A. W. Cooper.
Board of Governors—H. H. Bullock, E. H. Kendall, A. G. Orear, W. E. Barnum.
Entertainment and Speakers Committee—E. H. Kendall, *Chairman.*
Membership Committee—W. E. Barnum, *Chairman.*
Finance Committee—O. W. Ott, *Chairman.*
Air Conditioning Code Committee—A. H. Simonds, *Chairman.*

Meetings held during the past season have been outlined by Secretary Hendrickson.

November 12, 1935. A noon meeting was devoted mainly to the election of the present officers. The remainder of the meeting was taken up with a discussion of the research paper, Comfort Standards for Summer Air Conditioning. Attendance—22.

December 10, 1935. The speaker was P. J. Washburn, acoustical engineer, Johns Manville Co., who discussed Acoustical Treatment and Sound Control. Attendance—39.

January 14, 1936. The idea of formulating an Air Conditioning Code for Southern California was brought up and A. H.

Simonds was nominated chairman of the committee. F. M. Locher, Pacific Mutual Life Insurance Co., presented five reels of travel movies taken by himself and lectured to the membership concerning the interesting points of each. Attendance—24 members and guests.

February 18, 1936. The preliminary draft of the proposed Air Conditioning Code for Southern California was presented to the membership. Following discussion of this subject, A. W. Griewe, president, Los Angeles Speakers' Club, gave an interesting and educational talk on the subject of Public Speaking as an Asset in Business. Attendance—35 members and guests.

March 10, 1936. This meeting was devoted to a round table discussion of the proposed Southern California Air Conditioning Code. A number of changes were suggested and the committee was instructed to make a redraft to be presented at a later meeting. Attendance—28 members and guests.

April 7, 1936. This meeting was in honor of Pres. G. L. Larson's visit to the Southern California Chapter and 42 members and guests were present. President Larson, of Madison, Wis., was introduced by O. W. Ott, Council member, who gave an interesting resumé of Professor Larson's career. After giving the membership a short description of the Society's work, President Larson discussed The Economics of Good Construction as Related to Residence Heating.

May 12, 1936. The speaker of the evening was Pedro Cezon, president, Export Corp., Ltd., who spoke on the subject of Latin American Relations in Connection with Foreign Trade. One of the local Chapter members, M. I. Blumenthal, enlivened the meeting with a few of his own experiences in heating, ventilating and refrigeration work in South America. Copies of the revised draft of the proposed Air Conditioning Code for Southern California were distributed to the members.

June 9, 1936. The last meeting of the season was held with 23 members and guests present, and was devoted to a final discussion of the proposed Air Conditioning Code and methods of enforcement of the Code.

Washington, D. C.

October 14, 1936. The regular meeting of the Washington, D. C. Chapter was held at the Hotel Harrington, Washington, D. C. with 25 members and guests present at the dinner at 6:30 p.m. and 60 at the meeting following the dinner.

Col. W. A. Danielson, who recently returned from a trip to Alaska, gave a talk illustrated with lantern slides on the various climatic conditions and foremost industries found in the territory. Alaskan building construction practices and the usual methods of heating and ventilating were shown and the members were given some data on the cost of steam and electricity.

At 8:30 p.m. the regular business meeting was called to order by President Danielson and the minutes of the preceding meeting were read and approved.

T. H. Urdahl presented the report of the Program Committee emphasizing the benefits to the Chapter of talks prepared and presented by local talent, and all members desiring to present papers were asked to communicate with L. S. Ourusoff. Program plans for the next few months are as follows: *November*, 1936—Papers and Discussion—Forced Hot Water Heating for Residences, and Large Commercial Installations; *December*, 1936—Papers and Discussion—Greenhouse Heating; *January*, 1937—Paper on Comfort Conditions—Discussion of paper prepared by Research Committee of the Society; *February*, 1937—Paper on Glass Blocks.

Treas. W. E. Kingswell reported a net balance in the Chapter treasury of $20.60.

R. H. Feltwell, chairman of the Membership Committee, reported that 15 new members have been admitted to membership since the last meeting of the Chapter in May, 1936.

A discussion was held as to the most convenient time for the monthly dinner meeting, and R. H. Feltwell moved that the dinner start at 6:15 p.m. The motion was seconded by E. J. Febrey and passed.

The Chapter went on record as favoring acceptance of an invitation from the May Oil Burner Corp. to visit their plant. Arrangements are to be made for making the trip on a Wednesday evening.

J. B. Hewett, General Electric Co., a member of the Washington, D. C. Chapter was introduced by President Danielson and presented a well prepared paper on Methods of Design and Installation of the Air Conditioning System of the Hotel Harrington.

The meeting adjourned at 9:30 p.m., after which an inspection was made of the air conditioning installation of the Hotel Harrington. The members then returned to the auditorium to continue a general discussion of the design and methods used.

Fractional Horsepower Motors Subject of Philadelphia Chapter Meeting

October 8, 1936. The regular meeting of the Philadelphia Chapter was held at the Engineers Club at 8:10 p.m. with Pres. W. F. Smith presiding.

President Smith introduced Mr. Donnelly who spoke in behalf of the American Red Cross, after which R. C. Bolsinger commented on the success of the Semi-Annual Meeting of the Society held at Buck Hill Falls.

Secy. H. H. Erickson read a communication from the Technical Service Committee requesting the registration of members of the affiliated societies in need of employment.

L. P. Hynes outlined a proposed inspection trip by members of engineering societies of the S. S. Queen Mary on November 3, 1936 and extended an invitation to members of Philadelphia Chapter to attend.

A. E. Kriebel, Chairman of the Membership Committee reported the election of three members to the Chapter.

President Smith then turned the meeting over to C. B. Eastman, Chairman of the Meetings Committee, who introduced the speaker of the evening, B. S. Weaver, Industrial Engineering Department, General Electric Co., Schenectady, N. Y. Mr. Weaver presented a paper entitled, Fractional Horsepower Motors—Their Selection and Application to the Heating, Ventilating and Air Conditioning Industry, which was illustrated with slides.

This meeting which was attended by 50 members and guests was adjourned at 9:45 p.m.

Fuel Exposition for Coal Dealers at Chicago

Representatives of 40,000 retail coal merchants, producers, wholesalers and equipment manufacturers from 20 states were in attendance at the fuel exposition held at the Stevens hotel, Chicago, Ill., Sept. 21-26, during the second annual convention of the American Bituminous Retail Coal Merchants Association.

The development of coal as a fuel, the labor saving features of the latest in automatic heating equipment and the advances made by science toward the ultimate saving of millions of dollars annually to consumers were graphically demonstrated in displays arranged by 80 exhibitors. George I. Methe, Chicago, was reelected president of the association, and other officers reelected are: J. Atlee Schafer, Cleveland, first vice-president; Paul Conrades, St. Louis, second vice-president; Ward Lucas, Winona, Minn., third vice-president; Richard Bloedel, Fond du Lac, Wis., fourth vice-president, and Oscar Swenkerud, Chicago, last year's secretary who was named as secretary and treasurer for the coming year.

E. Wever Dobson was named to succeed himself as chairman of the board. The other members reelected are: George I. Methe, J. Atlee Schafer, Paul Conrades, Ward Lucas, Richard Bloedel, George F. Colton, Rockford, Ill.; William Vail, Toledo; Samuel Dolton, Columbia, Mo., and William Davis, Columbus, O.

New members are: R. B. Hart, Minneapolis; Charles Cross, Indianapolis; George Kimball, Lansing, Mich.; Charles Kelley, Detroit, and T. B. Tejans, Pittsburgh.

CANDIDATES FOR MEMBERSHIP

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the JOURNAL of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 49 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn the Council, urge the members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by November 16, 1936, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ADAMS, B. P., Asst. Genl. Mgr., McDonnell & Miller, Chicago, Ill.	E. N. McDonnell W. G. Boales	W. A. Russell D. H. Painter (*Non-Member*)
ARMBRUSTER, F. T. W., Sales Engr., The Portsmouth Supply Co., Waverly, Ohio.	D. B. Poling P. M. Kimmell	D. H. Wyatt A. C. R. Poore (*A. S. M. E.*)
BENNETT, E. A., Sales Engr., American Blower Corp., New York, N. Y. (*Advancement.*)	F. T. Still Arthur Ritter	A. J. Offner O. O. Oaks
BLAS, R. J., Air Cond. Engr., Carrier-Brunswick Internatl., Newark, N. J.	W. H. Carrier Donald French	W. A. Grant L. L. Lewis
BOZEMAN, R. W., Engr., Lexington, Ky., (*Reinstatement & Advancement.*)	Perry West L. S. O'Bannon	J. W. May E. W. Bureau (*A. I. E. E.*)
CAIRNS, J. H., Asst. Sales Engr., Frigidaire Corp., Toronto, Ont., Can.	J. H. Fox M. W. Shears	G. A. Playfair Thomas McDonald
CAMERON, W. R., Dist, Mgr., L. J. Mueller Furnace Co., Milwaukee, Wis.	W. A. Russell C. W. Adams	L. R. Chase R. E. Pauling
CHENOWETH, D. M., Student, Purdue Univ., West Lafayette, Ind.	J. D. Hoffman W. T. Miller (*Non-Member*)	G. A. Young (*Non-Member*) H. L. Solberg (*Non-Member*)
CODY, H. C., Sales Engr., Pierce, Butler Radiator Corp., Philadelphia, Pa.	H. J. Faltenbacher A. E. Kriebel	M. F. Blankin H. H. Erickson
DES REIS, J. F., Field Mgr., Carrier-Brunswick Internatl., Newark, N. J.	L. L. Lewis R. E. Cherne	W. A. Grant E. V. Erickson
DICKINSON, TOM, Draftsman, York Ice Mach. Corp., Los Angeles, Calif.	H. M. Hendrickson W. E. Barnum, Jr.	N. W. Berglund A. W. Cooper
DUPUIS, J. R., Dist. Mgr., Trane Co. of Can., Ltd., Montreal, Que., Can.	G. L. Wiggs F. J. Friedman	G. E. Cole J. A. M. Robertson
FARBER, L. M., Design Engr., Natkin & Co., Kansas City, Mo.	Sidney Pines Carl Clegg	H. J. Nottberg H. E. Gould
FORRESTER, N. J., Chief Estimator, The Garth Co., Montreal, Que., Can.	F. G. Phipps G. L. Wiggs	C. W. Johnson T. E. McGrail
GONZALEZ, R. A., Mgr. Application Engrg., Airtemp, Inc., Dayton, Ohio.	I. C. Baker J. R. Hertzler	Anker Winther H. B. Orr (*Non-Member*)
HARBORDT, O. E., Sales Mgr., U. S. Supply Co., Kansas City, Mo.	Gustav Nottberg W. A. Russell	L. A. Stephenson L. R. Chase
HELMRICH, G. B., Mech. Engr., The Detroit Edison Co., Detroit, Mich.	J. H. Walker G. D. Winans	E. E. Dubry G. H. Tuttle
KURTZ, R. W., Air Cond. & Htg. Inspector, City of Minneapolis, Minneapolis, Minn.	J. C. Davidson F. B. Rowley	H. M. Betts A. B. Algren
LA ROI, G. H., JR., Corresponding Engr., McDonnell & Miller, Chicago, Ill.	E. N. McDonnell W. G. Boales	W. A. Russell D. H. Painter (*Non-Member*)
MADLEY, F. J., Asst. Contract Engr., Eastern Steel Products, Ltd., Montreal, Que., Can.	C. W. Johnson Leo Garneau	G. L. Wiggs G. H. Osborne
MANNARINO, ALBERT, Student, Pratt Inst., Brooklyn, N. Y.	J. W. Hunter (*Non-Member*) R. B. Dale (*Non-Member*)	Anthony Ferraro (*Non-Member*) G. J. Barth (*Non-Member*)
MARSHALL, A. G., Sales Engr., Trane Co. of Can., Ltd., Montreal, Que., Can.	G. L. Wiggs T. E. McGrail	G. E. Cole J. A. M. Robertson
McDONALD, A. K., Sales Engr., Standard Oil Co. of New Jersey, Washington, D. C.	W. E. Kingswell R. H. Feltwell	W. H. Butler (*Non-Member*) T. A. Waters (*Non-Member*)
McDONNELL, J. E., Sales Engr., McDonnell & Miller, Chicago, Ill.	E. N. McDonnell W. G. Boales	W. A. Russell D. H. Painter (*Non-Member*)
McKEEMAN, C. A., Asst. Prof. of Mech. Engrg., Case School of Applied Science, Cleveland, Ohio	G. L. Tuve L. T. Avery	M. S. Rather F. H. Vose (*A.S.M.E.*)
MOORE, D. R., Student, Purdue Univ., West Lafayette, Ind.	J. D. Hoffman G. A. Young (*Non-Member*)	W. T. Miller (*Non-Member*) L. V. Ludy (*Non-Member*)

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
MUELLER, H. C., Asst. Sales Mgr., Powers Reg. Co., Chicago, Ill. (*Advancement*).	E. W. Rietz C. E. Price	J. R. Vernon L. S. Ries
MUELLER, H. P., Pres., L. J. Mueller Furnace Co., Milwaukee, Wis.	W. A. Danielson E. A. Jones	G. D. Kingsland J. H. Volk
NICKLE, A. J., Sales Engr., Darling Brothers, Ltd., Montreal, Que., Can.	A. B. Darling F. J. Friedman	T. E. McGrail F. G. Phipps
OGARD, N. L., Student, Univ. of Minn., Minneapolis, Minn.	F. B. Rowley A. B. Algren	J. V. Martenis B. J. Robertson (*Non-Member*)
PRAWL, F. E., Sales Engr., Sidles Co., Lincoln, Nebr.	M. J. Stevenson I. C. Baker	A. K. Snyder H. B. Orr (*Non-Member*)
PRINCE, R. F., Engr., Order Dept., American Radiator Co., Boston, Mass.	W. F. Gilling, Jr. N. J. H. Shaw	P. A. L. Foulds Adolph Ehrenzeller (*Non-Member*)
ROSS, J. D., Sales Engr., Railway & Engrg. Specialties, Ltd., Montreal, Que., Can.	G. L. Wiggs C. W. Johnson	T. E. McGrail F. G. Phipps
RUGGLES, R. F., Dist. Mgr., Autovent Fan & Blower Co., New York, N. Y. (*Reinstatement & Advancement.*)	Tom Brown A. F. Hinrichsen	W. M. Heebner H. B. Eells (*Non-Member*)
SCHERRER, K. C., Design Engr., Natkin & Co., Kansas City, Mo.	Sidney Pines Carl Clegg	H. J. Nottberg H. E. Gould
SCHUETZ, C. C., Research Engr., U. S. Gypsum Co., Chicago, Ill.	C. E. Price J. R. Vernon	Tom Brown J. H. Milliken
SKAGERBERG, RUTCHER, Market Development Engr., Brown Instrument Co., PennWynne, Pa. (*Reinstatement*).	H. F. Dever E. L. Hogan	H. E. Gerrish G. C. Morgan
SPARKS, J. D., Sales Engr., Ilg Elec. Vtg. Co., Chicago, Ill.	R. D. Morse Lincoln Bouillon	W. E. Beggs D. C. Griffin (*Non-Member*)
STILES, G. S., Sales Engr., Sidles Co., Airtemp Div., Des Moines, Iowa.	M. J. Stevenson I. C. Baker	A. K. Snyder H. B. Orr (*Non-Member*)
SWANSON, N. W., Sales Engr., McDonnell & Miller, Chicago, Ill.	E. N. McDonnell W. G. Boales	W. A. Russell D. H. Painter (*Non-Member*)
TIMMINS, W. W., Dist. Mgr., Canadian Powers Reg. Co., Ltd., Montreal, Que., Can.	G. L. Wiggs W. U. Hughes	C. W. Johnson A. F. Lamontagne
VELTMAN, B. M., Htg., Design & Sales, Brown Sheet Iron & Steel Co., St. Paul, Minn.	Albert Buenger R. E. Backstrom	H. E. Gerrish C. E. Gausman
WERNER, R. K., Consulting Mech. Engr., R. K. Werner, Cons. Engr., Ft. Worth, Texas.	F. E. Giesecke W. H. Badgett	H. B. Friedman (*A.S.C.E.*) P. M. Geren (*A.S.C.E.*)
WESLEY, R. O., Sales Engr., U. S. Radiator Corp., Seattle, Wash.	S. D. Peterson Lincoln Bouillon	M. J. Hauan D. C. Griffin (*Non-Member*)
WHITT, S. A., Air Cond. Engr., Kelvinator Corp., Detroit, Mich.	H. F. Hutzel C. A. Rickner	Roy Conrad C. L. Toonder
WILEY, D. C., Engr., John J. Nesbitt, Inc., Chicago, Ill.	J. F. Tobin J. E. McClellan	A. J. Nesbitt M. W. Bishop
WILKINSON, ARTHUR, Mgr., Messrs. Wilkinson Engrg. Agencies, Montreal, Que., Can.	G. L. Wiggs C. W. Johnson	Leo Garneau A. B. Darling
WILSON, ALEXANDER, Consulting Engr., Montreal, Que., Can.	G. L. Wiggs F. J. Friedman	C. W. Johnson G. H. Osborne
YOUNG, H. J., Sales Engr., Young Radiator Corp., Muskegon, Mich.	H. F. Reid E. I. Adams	L. G. Miller S. H. Downs

Candidates Elected

In past issues of the JOURNAL of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each Candidate has been assigned by the Committee on Admission and Advancement and ballotted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-III, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

BERZELIUS, C. E., First Lt., U. S. Army, Minneapolis, Minn.

JAMES, R. E., Mgr. Htg. Dept., Harry Cooper Supply Co., Springfield, Mo.

KING, A. C., Consulting Engr., Chicago, Ill.

LEONHARD, L. W., Supervisor (Paper Sens. Dept.), Eastman Kodak Co., Rochester, N. Y.

MILLS, DR. C. A., Prof. Experimental Medicine, Univ. of Cincinnati, Cincinnati, Ohio.

PHILLIPS, R. E., Consulting Mech. & Elec. Engr., Los Angeles, Calif.

STORMS, R. M., Consulting Engr., Storms & Gibbs, Los Angeles, Calif.

SYDOW, L. J., Owner, Colonial Htg. & Sheet Metal Co., St. Louis, Mo.

WALSH, MALCOLM, Vice Pres., Walsh & Wertheim, New York, N. Y. (*Reinstatement*).

WILSON, E. D., Gen. Mgr. in India, Carrier Engrg. Co., Ltd., London, S. W. 1, England.

WYATT, D. H., Consulting Mech. Engr., Columbus, Ohio.

ASSOCIATES

BARNES, H. P., Mgr., Johns Manville Sales Corp., Kansas City, Mo.

BARNSLEY, Mgr. Htg. & Cooling Div., Can. General Elec. Co., Montreal, Que., Can.

ESTES, E. C., Mech. Draftsman, Northern Pacific Ry., St. Paul, Minn.

GRIESSER, C. E., Owner, C. E. Griesser, Elec. Contractor Dealer, Bryan, Texas.

HILDRETH, E. S., Air Cond. Promotional Engr., Indianapolis Power & Light Co., Indianapolis, Ind.

MALONE, J. S., Dist. Sales Repr., Hoffman Specialty Co., St. Louis, Mo.

MCCRAE, G. W., Engr., John McCrae Mach. & Fdry. Co., Lindsay, Ont., Can.

MESSENGER, T. I., Power Engr., Buffalo Niagara & Eastern Power Corp., Buffalo, N. Y.

NELSON, E. L., Engrg. Dept., The Union Ice Co., Los Angeles, Calif.

WATERS, F. A., Sales Engr., Automatic Appliance Corp., Stamford, Conn.

JUNIORS

BROWN, D. M., Mech. Draftsman, Northup & O'Brien Archts., Winston-Salem, N. C.

FIGGIS, T. G., Mgr. Air Cond. & Refgr. Dept., Malcolm & Co., Ltd., Shanghai, China.

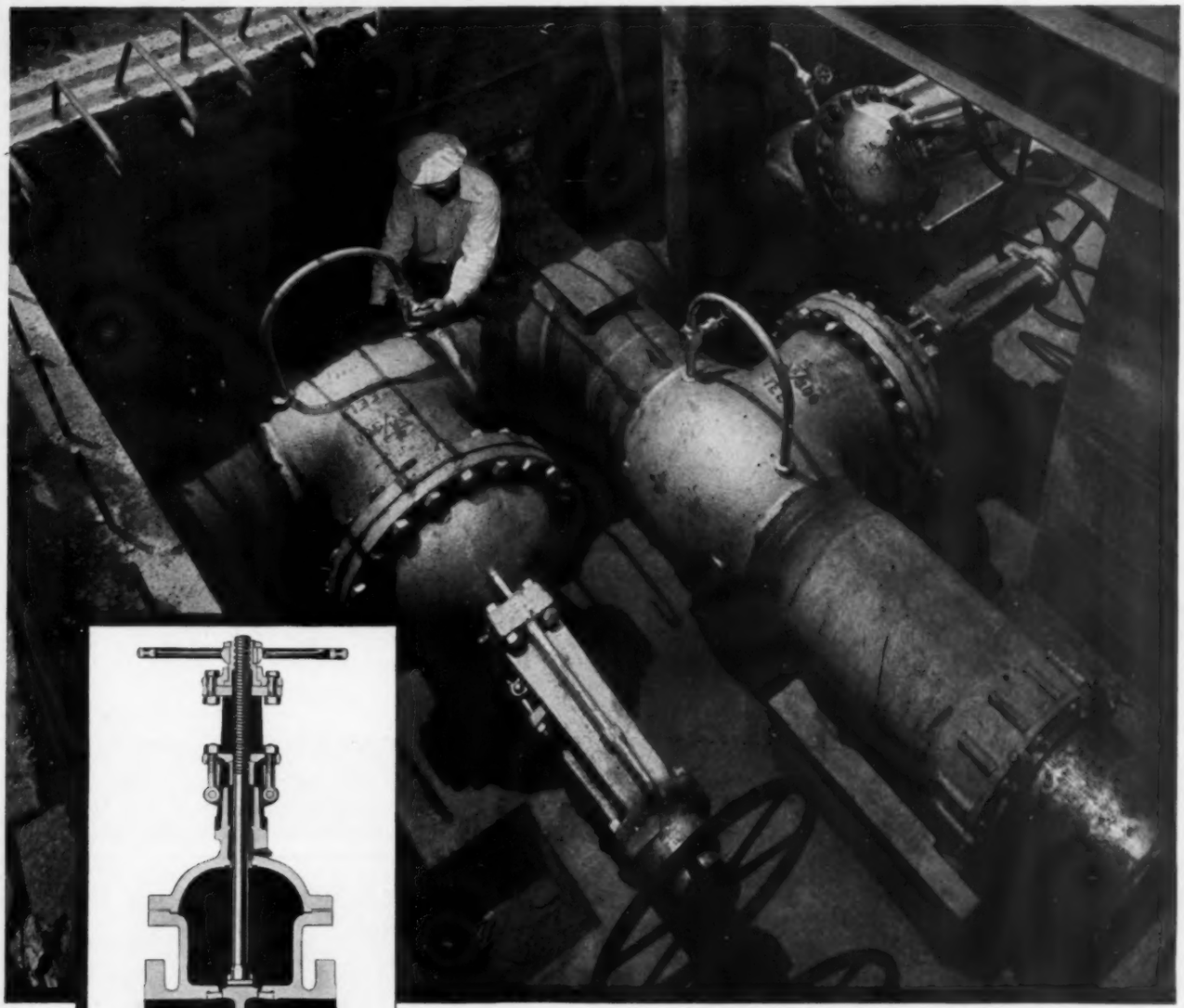
HAUCK, E. L., Sales Mgr. & Engr., Hauck Bros., Springfield, Ohio.

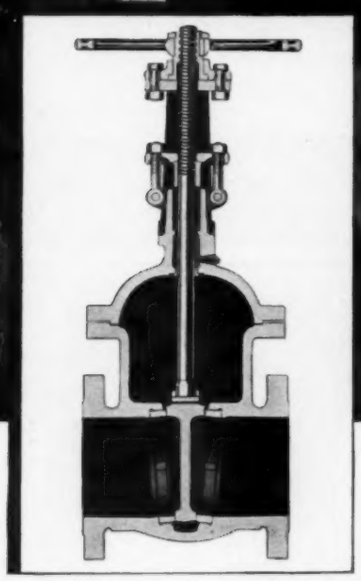
LOCHHEAD, K. Y., Supt. of Bldgs., Hudson's Bay Co., Winnipeg, Man., Can.

SICKERT, G. D., Acting Mgr. Htg. Div., Perfex Radiator Corp., Milwaukee, Wis.

TODD, M. L., Htg., Vtg. & Air Cond. Engr., Waterloo, Iowa.

WAHRENBROCK, O. K., Air Cond. Engr., Automatic Appliance Corp., Stamford, Conn.





We are *Design* originators in heavy duty valves . . .

● Here are shown Reading 300 lb. Cast Steel Gate Valves with welded ends in a steam distribution system running under city streets—welded in—dependably.

The interior view above left illustrates the general features of a design which in all its details has been developed for high temperature service. They do not stick or bind. No matter how heavy the load, they are always easy to operate—definite and positive in control.

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READING-PRATT & CADY COMPANY, Inc.

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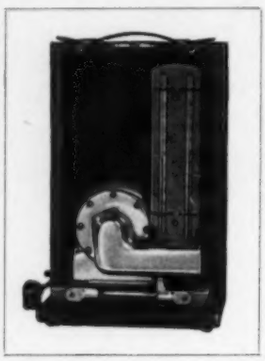
IN BUSINESS FOR YOUR SAFETY

READING • PRATT & CADY VALVES

Equipment Developments

For your convenience in obtaining more information about any of this equipment, see coupon on page 142. Add the new products and companies listed here to your Directory Section which you received in your January 1936 HEATING, PIPING AND AIR CONDITIONING and thus keep your records of sources of supply up to date throughout the year . . . Single asterisk (*) indicates equipment not listed in Directory Section; double asterisk (**) equipment and manufacturer not listed.

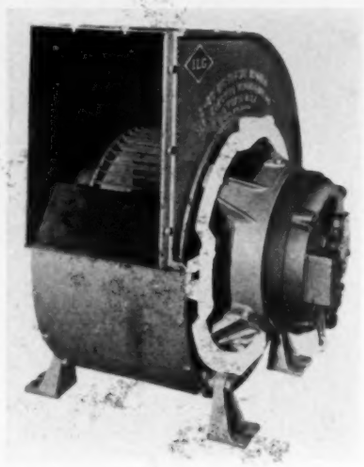
Motor Operated Aspirating Psychrometer



No. 1094*—Accurate relative humidity readings in one minute may be had with new motor operated aspirating psychrometer for air conditioning work, according to the manufacturer. It is offered in two portable types, one a self-contained battery model and the other for plugging into a 110 volt, 60 cycle source. Air is drawn across the bulbs of two easy reading, canary colored mercury thermometers by a small motor driven fan, passing first over the dry bulb and then the wet bulb. A cross-flow air movement is used, states the maker, to minimize the effect of the human breath and body heat on the instrument.

The thermometers are calibrated in single degrees from 30 to 120 F. Front part of carrying case is removable. Table for computing relative humidity and pocket slide rule for determining direct reading of relative humidity furnished with each instrument. Plug-in type is 6½ in. wide, 4¾ in. deep, 10½ in. high and weighs 4½ lb. Battery type is 6½ in. wide, 7 in. deep, 11 in. high and weighs 9 lb.—H-B Instrument Co., Inc., 2518 N. Broad St., Philadelphia, Pa.

Floated Drive Bracket Quiets Blowers



No. 1095—New sound and vibration dampening device for a direct connected blower, known as "floated drive bracket" is intended for use where extraordinary precautions must be taken for quiet operation. The standard motor bracket is mounted on a second floating bracket which is insulated from the blower housing to which it is secured by flexible rubber cushions.

The floated drive can be obtained as original equipment on any Ilg type B or type BC direct connected universal blower. Can also be mounted on any of these blowers already in service.—Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago, Ill.

Electrode for Welding 4-6% Chrome Steels

No. 1096—4-6 per cent chromium steels, used in applications requiring resistance to crude oil corrosion at high temperatures

NOTHING LIKE IT EVER PRINTED
The New Frick Catalog of Ammonia Valves and Fittings
Showing flanged pieces, both separately and complete with companion flanges, bolts and gaskets . . . with weights and principal dimensions listed in the same tables . . . and with only one discount applying to everything . . . Frick Catalog H is the answer to your need for a manual of valves and fittings that is convenient to use. Many new items, including repair parts for valves, are presented.
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SPECIFY —

RHOADS TANNATE-ROCKWOOD DRIVES for VENTILATING and AIR CONDITIONING

RHOADS TANNATE

In Tannate Belts pliability, strength, grip and durability are combined in an unusual degree.

For **fans,** pumps or compressors there is probably no prime-mover unit more efficient than a Tannate-Rockwood short-center drive. It saves floor space, seldom needs adjustment or other maintenance care and lasts longer under full load or overload conditions than either oak or V-Belt installations.

The Tannate-Rockwood unit consists of a motor mounted on a Rockwood pivoted motor base and belted with a Rhoads Tannate Leather Belt. The high efficiency of this combination is largely due to the outstanding qualities of the Tannate Belt.

Compared with other makes, Tannate Belt is usually much more durable at hard service with far greater overload capacity and a dependability seldom found in oak or multiple V-Belts.

SAVE BY MODERN GROUP DRIVES

J. E. RHOADS & SONS
PHILADELPHIA. 35 N. SIXTH ST.
NEW YORK, CHICAGO, ATLANTA, CLEVELAND, WILMINGTON, DEL.

and pressures, can be successfully welded by use of new "Chromeweld 4-6" electrode just announced.

The coated electrode contains the essential element of molybdenum and provides weld metal possessing the necessary high creep strength and other qualities essential for welding these steels, states the maker. Such steels welded with the electrode can be soft annealed to physical properties similar to those of mild carbon steel, and therefore rendered suitable for equipment where severe cold working is applied during fabrication.—Lincoln Electric Co., 12818 Coit Rd., Cleveland, Ohio.

Flexible Drive Shaft

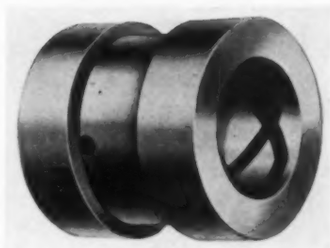
No. 1097**—New all-metal needle-bearing flexible drive shaft is said to compensate angular misalignment up to 20 deg while transmitting any horsepower up to 250. Endwise movement up to 1½ in. does not affect operation. Four needle bearings operating in oil take the place of leathers ordinarily used in couplings. Lengths from a few inches to several feet are standard designs.

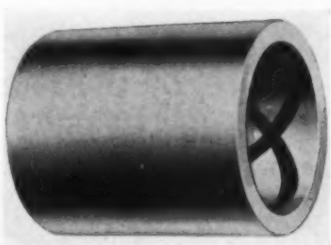
Unit is adapted to all types of drives including blowers, pumps, etc., according to the manufacturer—H. S. Watson Co., 525 Fourth St., San Francisco, Calif.

Oil Reservoir Graphite Bronze Bushings

No. 1098—Four types of oil reservoir graphite bronze bushings have been developed to enable automatic lubrication control by feeding lubricant from the reservoir through graphite plugs which regulate the rate of flow. Additional positive lubrication is supplied by graphite in machined grooves on the bearing surfaces.

Two of the bushings provide their own reservoir space by undercuts on the outside walls. Of these, one is designed for high speed installations or for intermittent use where lubrication is supplied only during assembly of the product or at long intervals. The other is designed for installations such as automotive water pumps and has lubrication for both bore and flange supplied through graphite feed plugs and graphite filled grooves.





The other two bushings are designed for applications where the oil reservoir is provided in the bearing housing. These bushings are also lubricated through graphite plugs and grooves. One is equipped for lubricating both the bore and the face of the flange.

All of these bushings can be reamed, broached or diamond bored after installation without damaging the graphite. Neither oil nor water will wash out the graphite or cause it to recede below the surface, says the maker.—Randall Graphite Products Corp., 609 W. Lake St., Chicago, Ill.

Modernistic Electric Air Heaters

No. 1099—"Modernistic" addition to line of electric air heaters are obtainable in any size necessary to fit the heating requirements of the room in which they are installed. A highly polished chrome finish or any color of enamel is available.

Element is of cast aluminum construction. Heating is done by means of a calrod, around which the aluminum grid is poured. Shrinkage of the metal in cooling causes the calrod to become an integral part of the heating element and eliminates hot wires and dead air space.

THE new way to trap unit heaters —using Super-Silvertop traps— saves from 40 to 60 minutes of installation time per trap and the cost of the extra fittings. Super-Silvertops make a beautiful, simplified installation and eliminate puzzlo piping.

In the above illustration the use of a Super-Silvertop trap saves three elbows and three nipples, besides installation time.

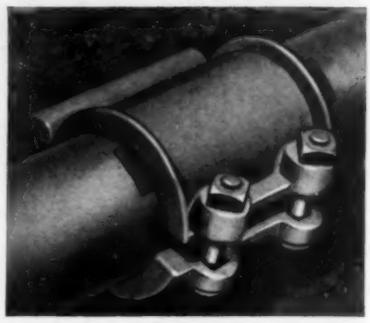
For your next unit heaters, investigate Super-Silvertops. They are easier to install, make a beautiful appearance, cost no more, operate on vacuum, stand up in service, need no strainer and they average 76% greater condensate capacity. This is the modern way to trap unit heaters.

Write today for further details and prices, no obligation.

THE V. D. ANDERSON CO.
1949 WEST 96th STREET • CLEVELAND, OHIO

Unit is of the built-in-type, with only the grille work exposed. Two methods of heating are incorporated in the design, (1) forced circulation, utilizing fan circulation, or (2) convection.—Electric Air Heater Co., Division of American Foundry Equipment Co., 555 Byrkit St., Mishawaka, Ind.

Pipe Repair Clamp Redesigned



No. 1100** — Redesigned pipe clamp for permanently stopping leaks in piping may be applied while line is in service, except upon extremely high pressure lines. The new specifications for these clamps require a metal of higher tensile strength, uniform density and hardness. Every clamp is tested under a pressure of 3000 lb before it leaves the factory, states the maker.

Clamps are available for stopping leaks in air, gas, steam, vapor, gasoline, oil, chemical, pulp, ammonia, brine and other types of pipe lines, high or low pressure.—M. B. Skinner Co., 3775 W. Sample St., South Bend, Ind.

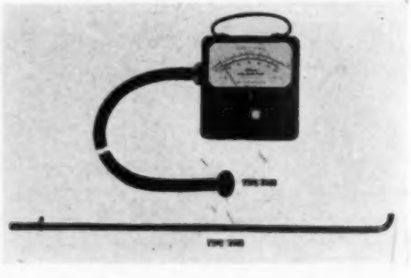
Non-Reversing Line Starters

No. 1101—New line of "De-ion" non-reversing line-starters, available in four sizes ranging from 25 to 150 amperes, are used for across the line starting of squirrel cage induction motors, and as primary switches for wound rotor induction motors. Typical applications include pumps, fans and similar machines where control is desired from a pushbutton or other pilot device with protection to operator, motor and machine.

Compact in design, the "De-ion" arc quencher confines, divides, and extinguishes the arc almost instantly without flash or scattering of flame, giving not only a high degree of safety but also practically unlimited life of arc box and contacts, according to the manufacturer. Vertical operation of the magnet prevents accidental closing of contacts due to mechanical shock or tilting. Motor protection is provided by new bi-metal thermal overload relay. Appearance is distinctive with rounded corners and vertical lines on cover.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

Attachments for Air Velocity Meter

No. 1102—Two new attachments for the "Alnor velometer" (direct reading air velocity meter) have been developed. One, (seen inserted in the meter) is used to obtain direct readings of static pressure of ducts, plenum chambers or pipes in inches of water. Static pressure is measured at right angles to the direction of the air flow. When this type of jet is furnished, with the tube type



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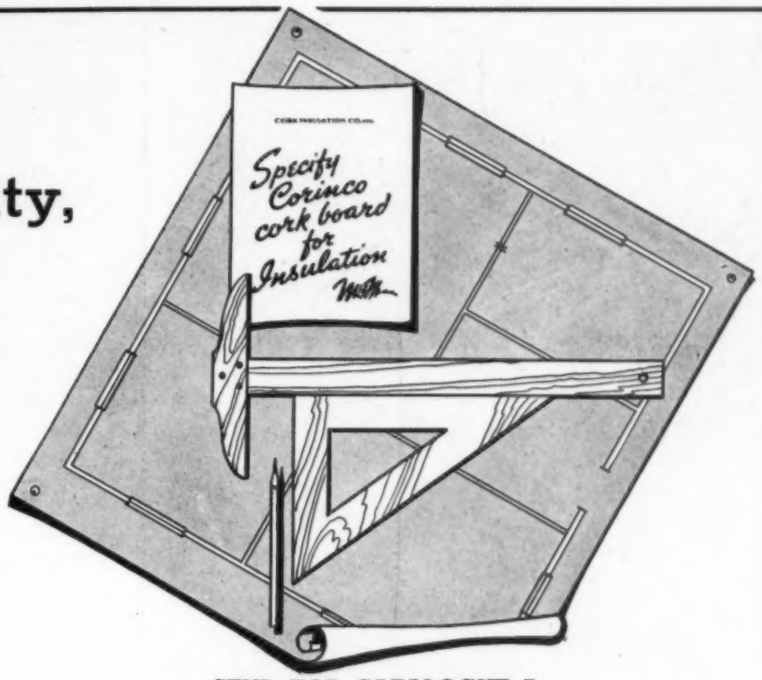

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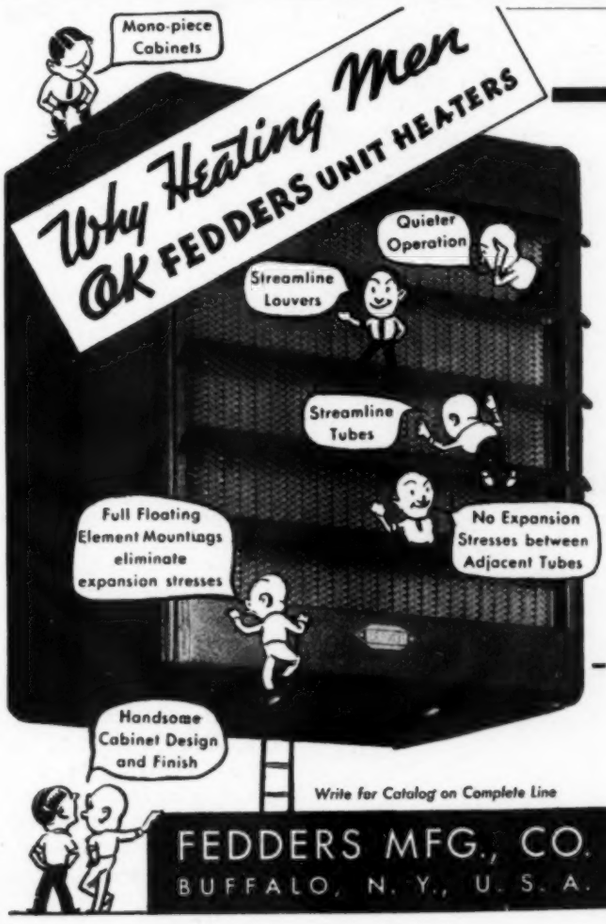
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Streamline tubes with convoluted fins increase aerodynamic and heat transfer efficiency. They also allow each tube to "give" laterally, thus preventing expansion stresses between neighboring tubes.

Tubes are welded to curved, non-diaphragmatic headers assuring maximum strength and a stable heating element.

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Ozite Duct Lining has an extremely high coefficient of sound absorption for the noises of fans and blowers in air conditioning systems.

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Both Ozite products are extremely simple to install. The hair felt can be cut and fitted quickly to any contour. Complete facts with detailed instructions for application will be sent upon request. Write today!

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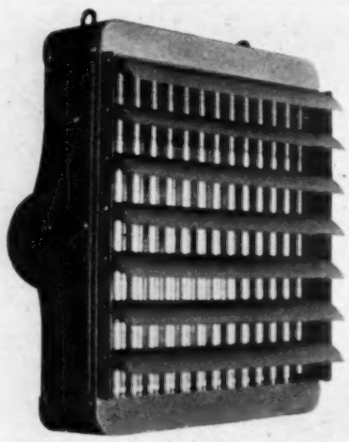
MERCHANDISE MART CHICAGO, ILL.

"velometer," an additional range of 0 to 2 in. is provided on the scale to accommodate the jet. This jet can be used for either positive static readings with the jet, tube and fittings attached to the left side of the "velometer" or for suction or negative readings with the jet, tube and fittings attached to the right side of the instrument.

The other type (at the bottom of illustration) when inserted in the air duct or chamber with the opening of the jet pointed directly into the air stream, gives direct reading of total pressure (static pressure plus velocity pressure) in inches of water. A separate range, 0 to 2 in., is provided on the scale when this total pressure jet is furnished. A small guide fin on the jet at the tube end aids in assuring that the opening of the end is in line with the air stream and facing into the air stream. Inch markings on the jet are provided to enable the user to place the jet at the desired distance within the duct.—Illinois Testing Laboratories, Inc., 419 N. La Salle St., Chicago, Ill.

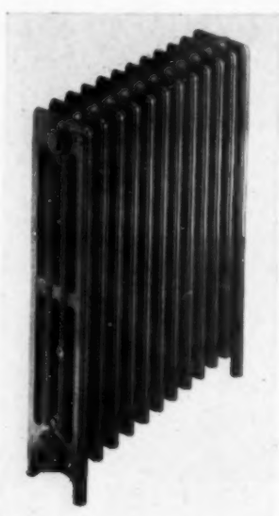
Unit Heaters Available in New Finishes



No. 1103 — Following demand for smart modern colorful finishes, the "Ilg" unit heater is now available in a series of special "de luxe" color finishes. It is expected by the maker that these colors, which include Spanish ivory, heather brown, silver, Pacific blue, etc., will prove of particular interest for use in offices, stores, restaurants, where the proper color can be selected to harmonize with the furnishings of the room. The finish is a special baked crackle.—Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago, Ill.

Small Tube Type Radiators

No. 1104—New, small tube type radiator (known as "National Art" line of radiation) is claimed to be truly artistic in design. The designer has utilized vertical lines and set-back planes; even the feet have been changed so that the design is carried uninterruptedly from floor to top.



Can be used either exposed or recessed and is particularly desirable for modernization work, as the units occupy less floor space, according to the manufacturer. It is claimed that the new radiators will work perfectly in conjunction with concealed heating units of the same system, and are found desirable in cases where concealed heating units are wanted on first floors and exposed or recessed types of units on upper floors.

The units are made in three widths: 3, 4 and 5 tube, and in heights ranging from 19 to 26 in. The radiators are of cast iron construction and are assembled in any length in multiples of 1½ in. The radiator is of push nipple construction, and can be furnished legless.—National Radiator Corp., 221 Central Ave., Johnstown, Pa.

Lincoln Bank Tower, Fort Wayne, Ind.

CENTRAL HEAT CONTROL CUTS COAL CONSUMPTION

Webster Moderator System Saves $781 in Lincoln Bank Tower During '35-'36 Season

Uses "Control-by-the-Weather"

Fort Wayne, Ind.—The Lincoln Bank Tower, equipped when built in 1930 with a modern vacuum system of steam heating, was further improved during the summer of 1935 with a Webster pneumatic-type Moderator System of Central Heating Control.

This improved system reduced coal consumption 150 tons during the 1935-36 heating season, equivalent to a cash saving of $781.50.

During 1935-36, with the Webster Moderator System, the cost of heating the Lincoln Bank Tower was $2,349.71. The old system for a comparable number of degree days would have required a fuel expenditure of $3,131.21.

The effectiveness of the Webster Control is indicated in the following summary:

	Lbs. Coal Fired	*Degree Days*	*Lbs. Coal Per D.D.*
1934-35—Before Webster Control..	1,073,520	6,046	177
1935-36—After Webster Control..	902.000	6,792	132

Investigation of comparable buildings led the management of the Lincoln Tower to the conclusion that addition of Webster "Control-by-the-Weather," with accurately sized metering orifices and convenient manual supply valves, would afford increased flexibility and at the same time effect a modest saving.

The results of the first season's operation show the objectives fully achieved. Comfort has been increased and wasteful window opening reduced to a minimum.

Schwegman-Witte Co., of Fort Wayne, acted as heating contractors. The architects of the building, when it was constructed, were Walker and Weeks of Cleveland and A. M. Strauss of Fort Wayne.

The first step in every Webster Heating Modernization Program is a careful investigation of existing steam-using facilities. When ample opportunity for steam savings is found to exist, Webster engineers work closely with owners, architects and heating contractors until the installation is completed and operating at maximum efficiency.

The Lincoln Bank Tower is one of 70,000 installations in which Webster Heating Systems and Webster System Equipment are providing fuel savings, comfortable indoor temperatures, and minimum repair and maintenance bills.

If you are interested in heating *new* buildings, or in improved heating service and lower heating cost in your present building, address

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39 Million Feet of Experience goes into the Making of AEROFIN Heat-Exchange Surface

The thirty-nine million feet of standardized light-weight heating and cooling surface manufactured by Aerofin in the past 13 years, represents a specialized experience in dealing with one of the important phases of the heating, ventilating and air conditioning industry.

Step by step over the years, Aerofin has improved, refined and enlarged its line to keep pace with the growing and diversified needs of this great industry. Pioneer in the introduction of modern fin-type heat exchange surface, Aerofin has always kept ahead by anticipating the practical requirements of architects, consulting engineers and heating contractors.

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You will find everything that you have always wanted in a heating surface in Aerofin. Let Aerofin's home office or any of its branches study your needs. The prompt, personal, technical co-operation of its engineers is at your service.

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Chicago Detroit New York Philadelphia

New Arc Welding Electrode

No. 1105—New electrode ("Universal Easyweld") has been especially designed for transformer type arc welders. Permits arc to be very easily started and maintained, does a dependable job on all repairs and maintenance work on steel or iron, and is ideal for light gauge steel welding, according to the maker.

These electrodes are of the protective shielded arc type, and produce weld metal of 55,000 to 65,000 lb strength with a ductility of 15 to 20 per cent elongation in 2 in.—Universal Power Corp., 1719 Clarkstone Rd., Cleveland, Ohio.

Dust Counter for Easy Determination of Dust Concentration

No. 1106—Without definite knowledge of actual dust concentration it is impossible to work intelligently on dust control. A dust counter designed to enable dust counts to be made easily and accurately without extensive laboratory training or experience by the operator has therefore been developed. The instrument combines in one unit the necessary air sampling device and dark field microscope viewing and counting system, mounted on a circular base, provided with illuminating apparatus and suitably cased for transportation or storage. Air is drawn through a moistening chamber by means of an accurately calibrated hand pump of 1/1000 cu ft capacity. The dust particles suspended in the air are impinged on a circular glass plate within the instrument in the form of a ribbon. Twelve samples may be collected on one slide, and may be viewed and counted at once without removal and may be preserved for future reference by sealing a cover glass to the slide.

The viewing and counting apparatus consists of a built-in compound microscope of 200X magnification with a special dark field illuminating system. The special hyper-plane eyepiece contains a micrometer disc ruled in 30 micron squares. An extra line, ruled next to the squares, permits approximate measurement of particles for classification as to size. The apparatus is so calibrated that by multiplying the number of dust particles in the square fields by 100,000 the total dust count per cu ft is secured.

The unit of dust measurement is the micron, 1/25,000 of an inch. Experimentation has shown that dust greater than 10 microns in diameter is practically harmless as far as the lungs are concerned, but the maximum amount of lung pathology may be expected from dust averaging between 2 and 5 microns. Such microscopic dust is, of course, invisible to the naked eye.—Bausch & Lomb Optical Co., Rochester, N. Y.

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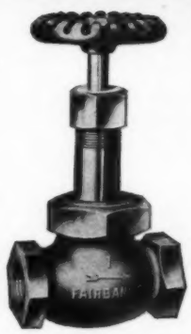
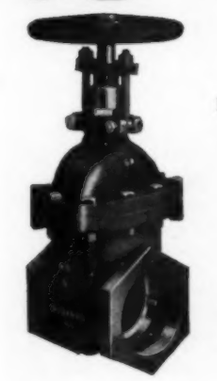
INDICATING LIGHT

All at your convenience in a small Master Station for the operation of Clark Automatic Control Panel for Multi-Speed A. C. Motors.

THE CLARK CONTROLLER CO. 1146 E. 152ND ST. CLEVELAND, O.





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Fairbanks Valves

Another reason for the remarkable accuracy, efficiency and staying power of Fairbanks Valves is that a large percentage of the men who make them have had between 20 and 40 years of experience. Their steadfast devotion to excellence has been passed on from father to son in scores of instances.

Everything must be *exactly* right before a Fairbanks Valve leaves the factory.

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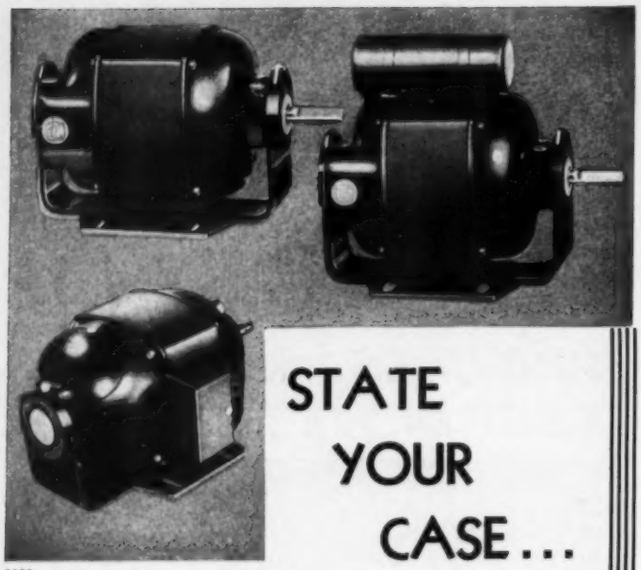

STATE YOUR CASE . . .

Regardless of the operating characteristics of the particular kind of heating or air-conditioning equipment you manufacture, the job calls for a particular kind of motor drive.

It is the business of Leland to meet such exacting motor requirements, and Leland maintains an experienced consulting engineering staff for that purpose. Those men are at your service—in position to bring years of experience to bear—in position to help you solve your problem.

State your case . . . be it the powering of a stoker, an oil burner, a blower, a unit heater, a propeller fan, or a complete air conditioning system. There is a Leland motor to drive it.

THE LELAND ELECTRIC CO.
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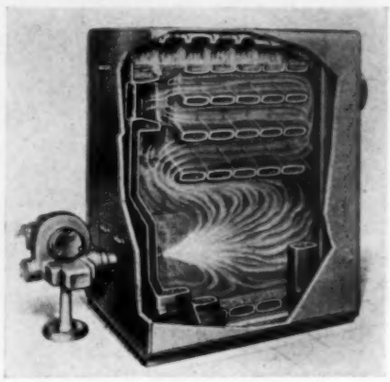
DAYTON . . . TORONTO . . . PARIS . . . MILAN

Oil Burning Boiler for Large Buildings

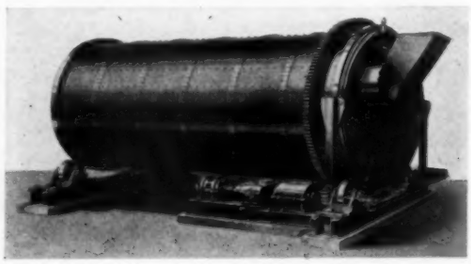
No. 1107—Oil burning boiler for use in apartment houses, office and industrial buildings, and large homes (called the "Pierce Oil No. 2"), will take care of any installation that requires up to 3000 sq ft of steam radiation.



Designed exclusively for the use of oil, the boiler is said to capture the greatest possible amount of heat due to the "five way" heat travel plus the added efficiency of a firing chamber completely surrounded by water. The flame makes two complete passes in the firing chamber and is then drawn three times through narrow flues equipped with fins for greater extraction of heat.—Pierce Butler Radiator Corp., 701 Nichols Ave., Syracuse, N. Y.

Rotary Louvre Dryer Available

No. 1108—Announcement has been made by Link-Belt Co. that it has acquired the manufacturing and sales rights for North America, for the Dunford & Elliott rotary louvre dryer, of which many installations have been made in Europe, Canada and Japan. It is being offered for the drying of all types of granular materials, coarse or fine, or of irregular shape, size and consistency; all types of crystals and powders manufactured or used in the chemical industry; factory refuse and waste; vegetable products, etc. It has also been employed as a heating or cooling unit; as a general reaction vessel; and for evaporating liquids on a solid substance. Among the materials handled are coal, coke, clay, fertilizers, grain, ores, cereals, salt, sand, sugar, wood chips and bark, cement clinker and chemicals.



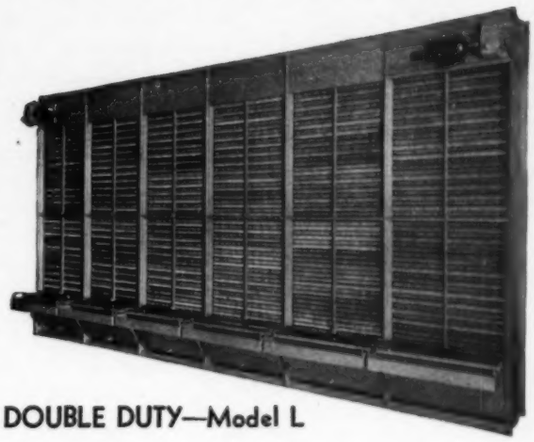
The dryer is described briefly as a mechanically rotated horizontal drum with a series of internal channels near the circumference, into which hot air is admitted from a fan. These channels are covered by tangential plates which overlap in such a way as to leave a gap for hot air to pass from the channels into the inside of the drum and into the material contained therein, and at the same time to prevent any material from falling backwards. The channels are tapered so as to give the inner lining of the drum a gentle slope from the feed end to the discharge end. As the drum revolves, fresh channels come underneath the charge, but, as the hot air can only enter the channels when they are actually underneath the charge, all the gases must pass upwards through the bed of material.—Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill.

Explosion Tested Fan Cooled Motors

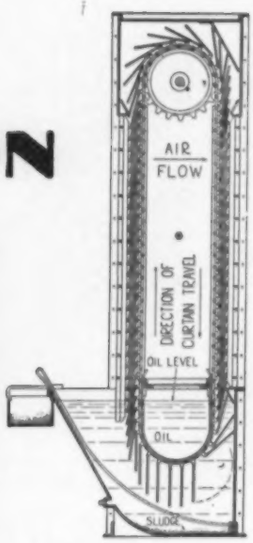
No. 1109—Improved design of explosion tested, fan-cooled, totally enclosed, direct current motors is available in sizes from 5 to 75 hp and 115,230 and 550 volts.

True IMPINGEMENT Air FILTRATION

The "DOUBLE DUTY" Model L air filter, illustrated on the right is particularly suited to heavy duty, large capacity, general ventilation installations in large buildings and industrial applications demanding strictly automatic operation. It's sturdy construction guarantees unlimited years of continuous, trouble-free performance. The Model L is built in single units of 5000 cfm. and may be operated in combination groups to meet any requirements.



DOUBLE DUTY—Model L



Cross-section thru filter, showing curtain operation, each curtain offering three acute air deflections.

"INDEPENDENT"

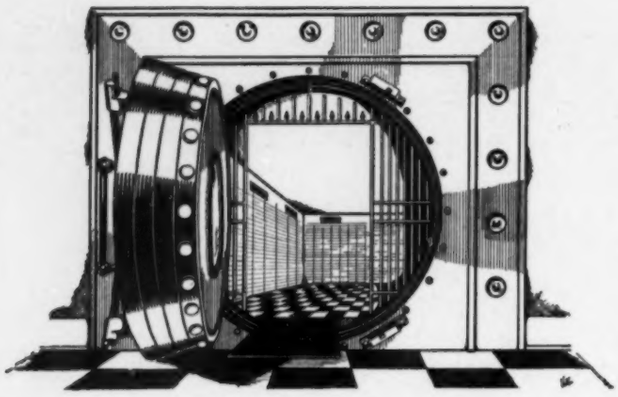
INDEPENDENT AIR FILTER COMPANY
215 WEST OHIO STREET, CHICAGO, ILLINOIS

BUSH·KNOWS·ALL·THE·MOVES

Because through years of experience devoted exclusively to the manufacture of fin surface we have developed the skill required for exact rapid and economical production.

Our individual fin principle enables you to purchase a coil built to fit the individual job at low cost and without delay.

THE BUSH MFG. CO., HARTFORD, CONN.
BRANCH FACTORY, 610 NO. OAKLEY BLVD., CHICAGO
BRANCH OFFICES, NEW YORK, DETROIT, CHICAGO, DAYTON, CLEVELAND, PHILADELPHIA AND LOS ANGELES



Keep Your Steam in a SAFE Place!

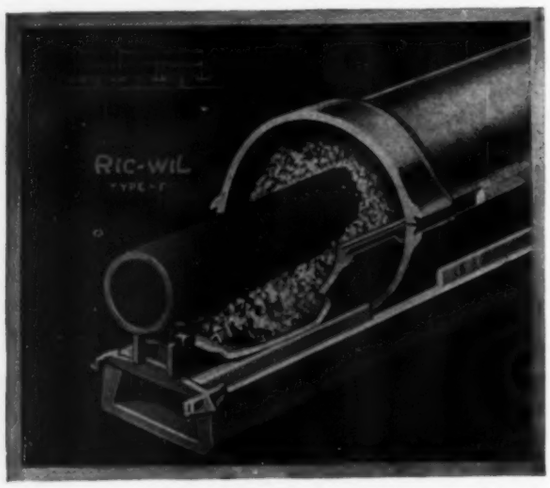
INVESTMENTS are always carefully put away in a safe place. Your steam in a power or heating system underground likewise represents an investment, which can show either dividends or losses. Safeguard your steam supply. Protect it from the ravages of water and corrosion, from leakage and loss. Ric-wiL Conduit will do this—Ric-wiL is a real and permanent underground Safety Vault for your steam.

26 years' experience gives the Ric-wiL Organization an invaluable advantage. Ric-wiL Systems are correctly engineered and drained—they keep steam lines tight, dry and over 90% efficient. Designs and materials in both tile and cast iron to meet all possible conditions. Obtainable with various insulations, including the famous Ric-wiL Watertight Asbestos Dry-paC. Ric-wiL service is complete from coast to coast—installation, engineering, field supervision. Write for complete catalog, with Dry-paC sample for testing.

The Ric-wiL Co. Union Trust Bldg. Cleveland, Ohio
New York San Francisco Chicago

Agents in principal cities.

According to competent authorities, heat loss from conduit in wet soil is over four times that in dry soil. Ric-wiL External Underdrain keeps the soil DRY.



REGISTERED IN U. S. PATENT OFFICE

RIC-WIL

CONDUIT SYSTEMS FOR UNDERGROUND STEAM PIPES

Brushes and commutator are readily accessible and motor is designed with fan on commutator and so that a gear case, coupling, or pulley will not restrict ventilation. Accessibility is obtained by use of double walled bracket on commutation end, which is equipped with removable hand hole covers to permit inspection and adjustment of the brushes and commutators.

These motors are designed, built and tested to withstand an internal explosion of gas (methane) or coal dust without injury to the equipment and without emitting flames or sparks which would ignite surrounding gas.—Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

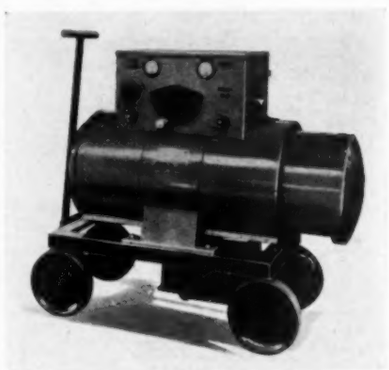
Humidistat and Water Valve Assembly

No. 1110**—A new item for use in air conditioning work comprises an assembly of a "Friez" insertion humidistat and a "Supreme" solenoid water valve to turn on and off the water supply as determined by the humidistat. The valve has been especially designed for this application and has a cast iron case with terminal chamber for BX connections.

Advantages of the combination are, according to the maker, attractive appearance and simplified installation, as only one electrical connection is necessary for the combined unit.—Supreme Electric Products Corp., 99 Mt. Hope Ave., Rochester, N. Y.

New Arc Welders

No. 1111*—A special separately excited revolving armature type synchronous motor built into the improved "Noel Speedarc" arc welders gives them a 100 per cent power factor at full load and leading power factors up to 40 per cent at no load for supplying power factor correction, according to the manufacturer, who states that in many industrial plants the entire cost of the welder can be absorbed in two years because of lower power bills resulting from high power factor operation.

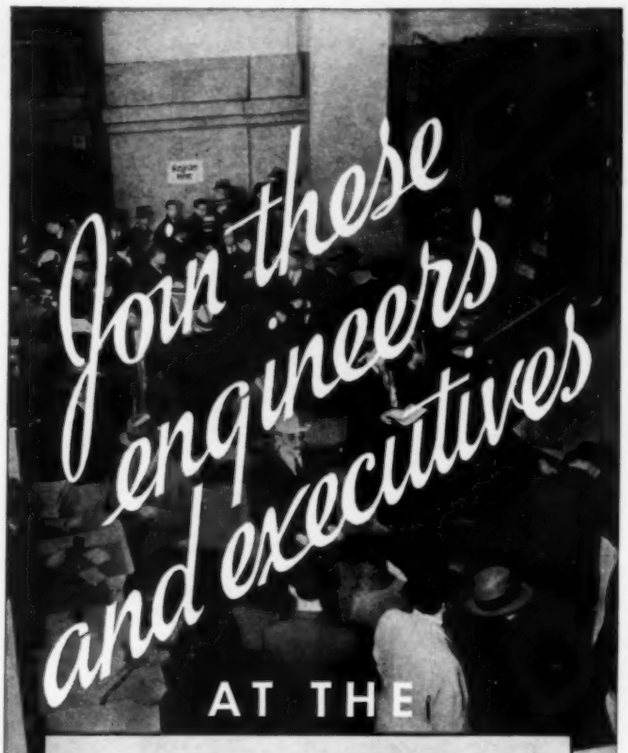


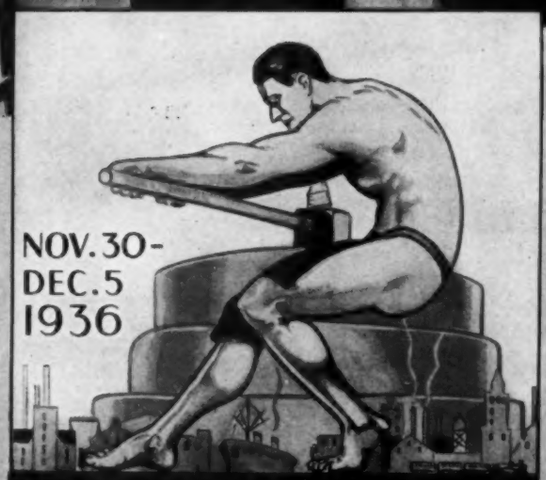
Another feature of the machine is that it will maintain its current and voltage settings when started up cold, and run full load for any period desired, which makes it unnecessary for the operator to continually adjust controls, and eliminates need for remote controls. A number of other features are included. Welder is built entirely of fabricated steel. 125, 200, 300 and 400 ampere units available.—Ideal Electric & Mfg. Co., E. First & Oak Sts., Mansfield, O.

Refrigerating Grids

No. 1112**—"Hydro-Thermal" sectional refrigerating grids for ammonia, freon, methyl chloride and other refrigerants have been designed to increase the useful storage space in brewery fermenting and storage rooms, wine cellars, fruit and vegetable storages, milk and dairy products storage rooms, cold storage warehouses, etc. Called "iceless finned coils," spacing of the fins and balancing of the fin surface to the actual tube surface in direct contact with the refrigerant has been designed so that only a thin layer of frost is collected, which is evaporated back into the air during the shut down period of the machine, states the maker. Three fin sizes (8x8, 6x6 and 3½x6 in.) are available in convenient stock lengths.

Features include atomic hydrogen welded throughout, entire grid hot galvanized after assembling, heavy fins with wide flange for perfect bond with tube, and convenient threaded connection at each end of every coil. They require only natural air circu-

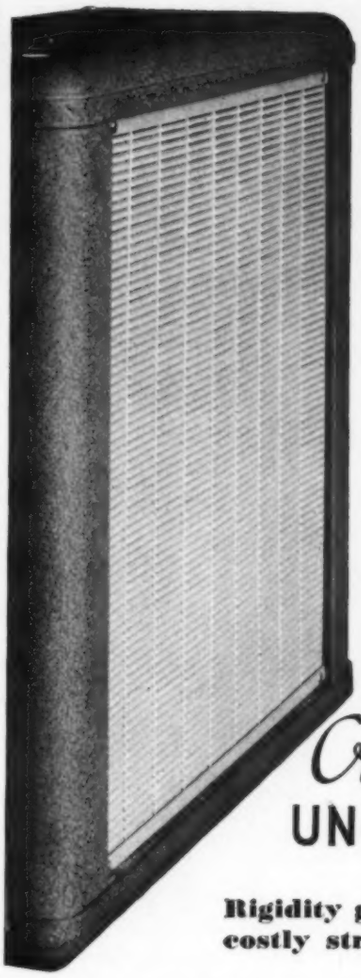




12TH NATIONAL EXPOSITION OF POWER AND MECHANICAL ENGINEERING
GRAND CENTRAL PALACE N.Y.

MANAGEMENT INTERNATIONAL EXPOSITION CO

OVER 300 exhibitors will show their newest products for modern power generation, transmission, control and application. Forty thousand engineers and executives are expected to attend. Plan now to join them.



UNRETOUCHED PHOTOGRAPH OF A TRANE CRADLE COIL UNIT HEATER — BUILT FOR THE OFFICE AS WELL AS THE FACTORY....

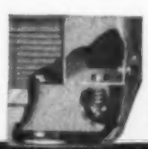
New Trane *Cradle Coil* UNIT HEATER

Rigidity goes-and with it costly stress and strain.

DEMAND unit heaters with a double life! Sturdy Trane Unit Heaters now give you a new factor of safety—Straight Line Expansion, made possible by the new exclusive Cradle Coil. The Cradle Coil is insurance against stress and strain due to expansion. Increases leeway in piping installation. Removes positively the rigid connection between casing and heater.

This feature is one of a long series of improvements contributed by Trane to industry. Solderless coils—high efficiency fans—Freeflo Grilles—Floor Line Spread. Units with beauty as well as utility; units that "fit" in the office as well as the factory.

Over sixty sizes! The largest line of propeller units commercially available.



The Coil is Spring Cradled in the Casing.

Write for data before you buy!

THE TRANE COMPANY

La Crosse, Wis. - - - - - 63 U. S. Branches
In Canada: Mowat & King Sts. W., Toronto

Gentlemen: Please rush complete data on Trane Cradle Coil Unit Heaters.

Name _____

Address _____

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HP11

BE IT MEN OR METAL

It's Service That Rates the Highest

The one a shaft in honor of men—the other the signature on a casting—both indicative of outstanding service.

And why "K" fittings! Because the analysis is right, the foundry practice is right, the inspection is right.

Because the line is complete and the inventory kept at a high level to care for heavy dispatch demands upon it. Use "K" fittings on that big job. You'll find them of uniformly high quality and a line that will make up easily and pull tight.

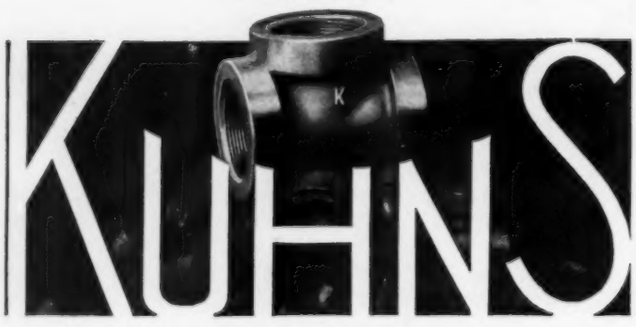
Standard and extra heavy screwed fittings, American Sprinkler fittings, standard flanged fittings, standard and extra heavy companion flanges and drainage fittings.

Combined marketing facilities on both "K" cast iron and M.I.F. malleables. Complete stocks of both at Dayton, Ohio, and Branford, Conn.

KUHNS BROTHERS COMPANY

Dayton, Ohio

Established 1887



lation, but can be used with forced air circulation.—Advanced Refrigerating Systems Co., Wilford Bldg., 33rd & Arch Sts., Philadelphia, Pa.

New Grille Can't Be Seen Through

No. 1113—New "Uni-Flo Sight-Tite" grille has been designed so that it cannot be seen through from any direction. Designed for minimum resistance to air flow, it is for use for door and interior wall ventilation apertures, and for exterior fresh air intakes. It is not suitable for air conditioning supply ducts.

The core is especially formed to produce openings for ventilating grille, and still shut off vision from any angle. Insofar as the manufacture is concerned, the bar and fin construction is identical with other types of "Uni-Flo" cores.—Barber-Colman Co., 225 Loomis St., Rockford, Ill.

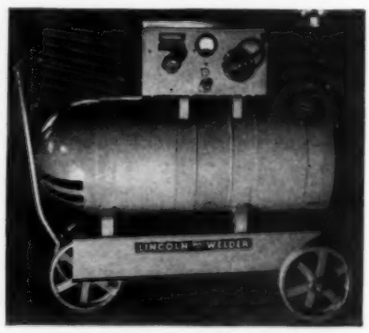
Mercury Switch of All Metal Construction

No. 1114**—A metallic envelope instead of a glass envelope is used in a new mercury switch for use in automatic electrically controlled devices for the purpose of preventing breakage. A liquid fill is utilized which, states the maker, eliminates gas leakage and false contacts.

The metallic envelope is encased in a molded bakelight insulator, and electric clearances are such that leakage or flashover will not occur when installed in wet places. It is designed to open and close at exactly specified angles which remain the same throughout the life of the unit and are independent of load.—Durakool, Inc., 1010 N. Main St., Elkhart, Ind.

Arc Welder Features New Method of Arc Control

No. 1115—New line of single operator arc welders known as "Shield Arc SAE" supersedes the previous type of "Shield Arc." The predominating feature is a new method of arc control which makes possible the adjustment of both arc heat and arc penetration in a continuous sequence of fine increments. According to the maker, this continuous dual control assures absolute uniformity of performance at every control setting.



Welders are available in the following types and ratings: A-C motor driven—200, 300, 400 and 600 amperes; d-c motor driven—300, 400 and 600 amperes; generator for belt or couple service—200, 300, 400 and 600 amperes; and engine driven—200, 300 and 400 amperes.—The Lincoln Electric Co., 12818 Coit Rd., Cleveland, O.

Rotary Pump for Many Services

No. 1116**—Rotary pump available in capacities of 5, 10, 20 and 35 gpm incorporates a positive displacement principle which has been worked out to eliminate insofar as possible friction by eliminating all sliding and grinding movements on both rotor and cylinder, and substituting a rolling movement. Thus, states the maker, high efficiencies are obtained.

This pump is self-priming up to a suction lift of 22 ft, and will produce, on water, a dead end vacuum of 29 in. at 30 in. barometer. The displacement mechanism consists of only two members, a rotor keyed to the shaft and a free rolling roller placed on top of the rotor. Pump is designed to operate on non-lubricant liquids to a maximum of 100 lb pressure, and recommended speed is 275 to 300 rpm. Furnished in either all iron or all bronze for air conditioning and industrial service, for handling acids, alcohol, ammonia, beer, brines, chemicals, gasoline, fresh and salt water, etc.—Anderson Rotary Pump Co., 120 Liberty St., New York, N. Y.

Coal Feeder for High Pressure Boilers

No. 1117**—New coal feeder ("Fyr-Feeder") has been designed for water tube or horizontal return tubular boilers. According to the manufacturer, features include the following: Designed for low set boilers; require no excavation, extend only 18 in., economically operated by fractional horsepower motor; can be fitted to practically any existing boiler front without ex-

pensive changes; can be hand fired at any time; burn any kind of coal—anthracite, bituminous, lignite, coke breeze. Coal fines are propelled into suspension where they are burned immediately above the grate, and over-fire air injectors provide air for instant combustion of fines in suspension.

Feeders adjustable; coal is fed in measured quantities above firing doors, distribution of the coal over the grate being accomplished by multiple pneumatic spreaders.—American Coal Burner Co., 161 E. Superior St., Chicago, Ill.

Pipe Thread Compound

No. 1118—New pipe thread compound known as "Nabico Joint-Seal" is a low priced pipe cement for general uses, such as for joints holding gas, air, hot water and steam, where reasonable pressure conditions prevail. Joints may be easily taken apart due to its continued elasticity, states the maker. It may be also used as a preservative dressing for flanges and joint packings.—National Boiler Improvement Co., 4100 Georgia Ave., Washington, D. C.

A. C. Unit for Stores and Offices

No. 1119—New type "all-in-one" air conditioning unit for shops, stores and offices introduced at the national hotel show, New York City, is of 3 hp capacity. Design is compact so that all machinery, including compressor, motor, condenser and cooling coils are contained in one cabinet which covers only 20 by 33 in. of floor space. Height is 7 ft. 6 in. The secret of compactness in the unit lies in a new reciprocating type radial compressor, so designed that it can be encased in the base of the cabinet,

Vilter

VERTICAL

COMPRESSOR

for

"FREON"

Outstanding in the field of industrial compressors for modern air conditioning applications where "Freon" is used as the refrigerant is this Vilter Vertical Freon Compressor.

The compact size and proportions of this unit make it ideal for installations where floor space and head room are a factor.

The long years of successful experience in the field of refrigeration and cooling equips this company to render unusual service in handling individually-engineered projects.

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2148 S. First Street
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MAIL THIS COUPON .. Today

We would like to know more about the Vilter Freon Compressor. Send us complete information.

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IF YOU WANT PIPE

IN LONG LENGTHS

On every piping job, there are places where long lengths will shorten installation time, reduce fitting expense and make possible neater work.

Now you can obtain pipe in extra long lengths—without cross-weld—Fretz-Moon Pipe. Because it is made by the exclusive "continuous process," it may be had in double random (or even longer) lengths. And not one bit of the well-known Fretz-Moon quality is sacrificed.

Every length, no matter how long, is straight as an arrow, true in size, perfectly round, uniform in structure, tightly welded, clean inside and outside, and easy to bend, cut or thread at any point. Every inch is as highly ductile as every other inch—without a single hard or burnt spot to cause trouble. It is ideal for coiling.

Fretz-Moon Pipe is available in long lengths in sizes from ⅛-inch to 2½-inch. Write for full information.

FRETZ-MOON TUBE CO., INC.
BUTLER • PENNA.

FRETZ-MOON
PIPE
BLACK AND GALVANIZED

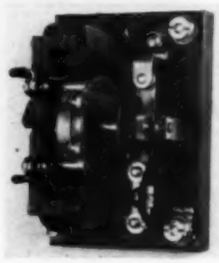
according to the maker.

The unit provides for overhead distribution of conditioned air, and for the circulation of 1200 cfm. An important feature is its semi-portability, which protects the interest of the merchant or shop owner by permitting him to take the unit with him from one building to another.—Airtemp, Inc., Dayton, Ohio.

Motor Operated Timing Devices

No. 1120—Two new timing devices have been added to this company's line, one of which is of the immediately recycling type and the other of the continuously rotating type.

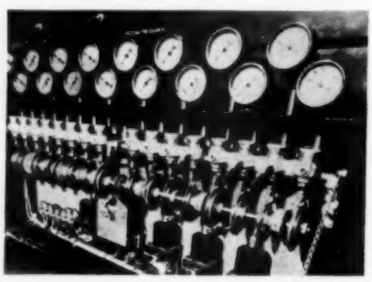
The immediately recycling timer consists principally of a small synchronous motor which drives a drum through a series of gears. The timing range is 5-100 sec, and its accuracy permits its use in practically any timing application, according to the manufacturer. It is glass enclosed, has switchboard mounting studs for rear connections and its base is 8¾ by 5½ in. Control line—110 volts, 60 cycles; contacts—110 volts a-c, 5 amperes.



The continuously rotating unit consists of a synchronous motor driving a cam which opens and closes a set of single pole, single break contacts at regular intervals as long as the motor circuit is energized. It is geared to make contact once every minute, but with proper gearing practically any time interval may be obtained. Control circuit—110 volts, 60 cycles; contacts rated at 110 volts a-c, 10 amperes.—Struthers Dunn, Inc., 153 N. Juniper St., Philadelphia, Pa.

New System of Complete Process Control

No. 1121—A new system, known as the "coordinated control system," has been developed for automatically operating all of the technical operations and factors of industrial processes that are developed in the laboratory and pilot plant, and depend on rigid control of the time of operations of valves, pumps, blowers, dampers, etc., and the control of temperature, pressure, liquid level, flow, and humidity.



The control system, an automatic machine built in the form of a master control station, consists of recording and controlling instruments built around the so-called "mechanical brain," all instruments being standard. The "mechanical brain" coordinates the efforts of instruments and automatically regulates all operations in the process, according to the maker.—The Bristol Co., Waterbury, Conn.

Louvre Incorporates High Velocity Principle

No. 1122—The "Punkah" louvre incorporates the principle of "high velocity delivery" of the ventilating air, involving speeds of 30 to 50 ft per sec, whereby the delivered air is completely mixed with the atmosphere of the space ventilated, thus making impossible a stagnant condition of the air, according to the manufacturer, who states that it takes the place of ordinary frets or grid louvres, as well as performing the function of propeller fan.

Three types are manufactured—"A" is in the "shut off" position when the nozzle is placed in the recess provided on the outer flange, "B" controls the output of the louvre by a specially shaped flap operated by a thumb-screw on the outside of louvre ball, and "C" gives an alternative form of control.

These louvres have been used on passenger ships, railways, in aircraft, lunch rooms, ballrooms, etc.—Kelvin & Wilford White Co., 90 State St., Boston, Mass.

Supplemental Dampers

No. 1123—Automatic control of air volume and velocity, balancing of air distribution and elimination of drafts in occupied spaces during operation of heating and ventilating systems is claimed to be obtained by "Brett-Gibbon" patented automatic volume dampers. They are applicable to central designs of heating, ventilating and air conditioning systems with the individual duct having mixing dampers, regulated and controlled by thermostats installed in the occupied spaces, and with an operating medium acting on a diaphragm motor which is attached to the damper blades.

These dampers provide economical and comfortable heating and ventilating, lower fuel expenditure, avoid air stratification and drafts, states the patent owner.—Thomas J. Brett, 7603 E. End Ave., Chicago, Ill.

Editor's Page—

[*Continued from page* 39, *front section*]

the filing and recording of an amendment to its certificate of incorporation, providing for its change of name to Public Utility Engineering and Service Corp., to become effective immediately. . . . Purpose of the change is to more clearly indicate existence of the corporation as a separate and distinct organization from H. M. Byllesby Co., the investment banking house.

■ **Copper**—F. S. Chase, president of the *Copper & Brass Research Association,* announced an increased consumption of products made from copper and its alloys during the first nine months of this year, at the annual meeting last month, and said the outlook for the fourth quarter and for 1937 is most encouraging. He pointed out that in normal times the building industry is a large consumer, and said that the outlook was for a considerable increase in the volume of building in 1937. . . . Officers of the association are president, Mr. Chase, president of Chase Brass & Copper Co., Inc.; vice-presidents, John A. Coe, president of American Brass Co., C. D. Dallas, president of Revere Copper and Brass, Inc., and Wylie Brown, president of Phelps Dodge Copper Products Corp. Mr. Dallas is also treasurer, and Bertram B. Caddle is secretary. . . . August sales of mechanical coal stokers totalled 9557 units, an increase of 52 per cent over the preceding month, according to statistics released by the U. S. Bureau of the Census and based on monthly reports furnished to the government by 108 manufacturers representing approximately 91 per cent of the total value of the industry. . . . New rates for electricity filed by the Commonwealth Edison Co., Chicago, are expected to stimulate installation of air conditioning units.

■ **Hospital A. C.**—According to a study of hospital air conditioning by E. L. MacQuiddy, assistant professor of medicine at the University of Nebraska, published in "Hospitals," patients suffering from hay fever and pollen asthma obtained sufficient relief to indicate that air conditioning will become an important adjunct to other methods of therapy, and post-operative cases had easier convalescences. From 10 to 20 per cent outside air is desirable in hospital air conditioning, according to Prof. MacQuiddy. . . . Believing that the problem of "over-cooling" is one of the most important facing the air conditioning industry, the Detroit Lubricator Co. has announced that it will devote much of its advertising to the importance of balancing inside temperature with outside to avoid over-cooling, shock, etc.

■ **Climafying**—The word "Climafy," coined by Albert N. Williams, won the prize offered by "Forbes Magazine" for a "useable single word to replace the term 'air conditioning'" . . . Over 3,000 words were submitted.

SIMPLE
POSITIVE
LOW POWER CONSUMPTION

The popular trend toward A-P Controls is but a reflection of the super features that have made them supreme in the field.

Designed to insure against leakage past the valve. Simple and positive in operation against high pressures, and functions perfectly with very low power consumption.

Write for complete Bulletin of types, sizes and applications.

Consult AUTOMATIC PRODUCTS CO.

Dept. HP-1 Milwaukee, Wisconsin

Send complete information on A-P Refrigerant Valves.

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Booklets, Reports and Papers

Revised Edition of A. C. Standards

A revised edition, dated October, 1936, of the Chicago Standards for Comfort Air Conditioning has been issued; these standards were originally dated October, 1935. Similarly, a revised edition of the supplement to the standards has been published; this supplement contains explanations and suggestions for engineers who are interested in designing systems that comply with the standards.

John Howatt, 228 N. La Salle St., Chicago, Ill., is chairman of the Chicago Committee on Air Conditioning Standards.

Manual of Smoke and Boiler Ordinances and Requirements

The *Smoke Prevention Association* has published an 80 page, paper-covered "Manual of Smoke and Boiler Ordinances and Requirements" in the interest of smoke and air pollution regulation and fuel combustion. Copies are available at 50c each. Included is information on the Ringleman chart for grading density of smoke, the code for rating steel heating boilers, headroom requirements for smokeless settings, questions and answers on smoke prevention, model smoke abatement ordinances, and firing instructions for firebox boiler operators.

Excerpts from several papers read at conventions of the Association are included. Among them are "Smoke Abatement Problems," by William J. Christy; "Stoker Requirements for Smoke Elimination," by T. A. Marsh; "Elimination of the Fly Ash Nuisance," by John F. Tobin; "The Effect of Smoke on Health," by E. L. Opie; "The Fireless Steaming System at Locomotive Terminals," by L. G. Plant; and "Principles in Boiler Design Essential to Smoke Elimination," by H. C. Carroll.

The secretary of the Association is Frank A. Chambers, Chief Smoke Inspector, City of Chicago.

Air Conditioning with Ice

A loose-leaf book entitled "Selling Iced Air Conditioning," by H. L. Lincoln and V. V. Ogburn and the staff of the Union Ice Co., has been published by the Union Ice Co., 354 Pine St., San Francisco, Calif. Copies are available at $2.25 each.

It is the publisher's viewpoint that there is a definite place in air conditioning for the use of ice as the cooling medium, and that this is determined partly by economics and partly by available service, the first factor being influenced by the size and the extent of use per year, and the second factor by the competently informed men who may be available in giving instruction in the performance of the equipment.

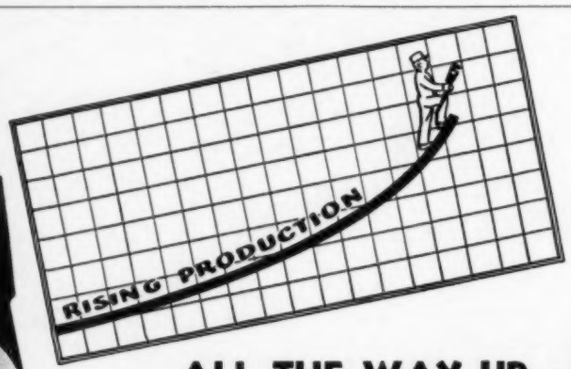
Part 1 of the book is devoted to photographs and descriptions of typical installations with brief statements of their performance. These installations include restaurants and hotels, theaters, offices and stores, funeral chapels and churches, beauty parlors and barber shops, hospitals and residences. The second part is devoted to instructions for promotional salesmen, in which the importance of engineering is stressed, and to a section entitled "Common Sense Engineering" presenting fundamental information on air conditioning engineering.

Combustion on Small Underfeed Stokers

Technical Publication No. 750 of the *American Institute of Mining and Metallurgical Engineers,* 29 W. 39th St., New York City, is entitled "Combustion of Bituminous Coal on the Small Underfeed Stoker," by Ralph A. Sherman and E. R. Kaiser of the Battelle Memorial Institute. This paper was presented at the Institute's Pittsburgh meeting, October, 1936.

The program of research at the Battelle Institute is outlined

When you buy wrenches, always look for the Red Tag attached to every TRIMO.



RISING PRODUCTION

ALL THE WAY UP — USE TRIMO

As the construction curve rises and with it the need for more heating piping and air conditioning work, you can count on TRIMO to meet your wrench requirements every step of the way.

No other wrench can equal in strength TRIMO'S construction of Chrome Molybdenum Steel — its drop forged handle. TRIMO has a replaceable jaw that saves you money—and teeth that have been tested for maximum grip.

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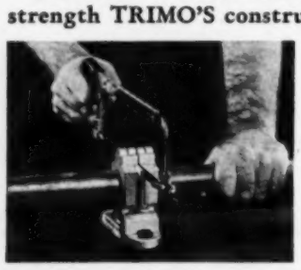

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Making every cut 100% square and eliminating waste of thin wall brass and copper tubing, TRIMO pays back its cost on the first job.

PLACE ONE RESPONSIBILITY FOR ALL BRONZE VALVES AND HEATING SPECIALTIES ON THE COMPLETE MILVACO LINE

MILVACO Heating Specialties and Approved Bronze Valves are made by specialists in the manufacture of brass and bronze valves for more than a third of a century. Each unit is made with precision accuracy and scientifically engineered to meet the most exacting service demands for which it is recommended.

A complete MILVACO installation insures uniform high operating efficiency. It is more economical to install MILVACO products . . . they are more efficient in operation and much more satisfactory for a longer period of time.

Take advantage of these savings and learn also, the greater dependability of MILVACO Heating Specialties and Approved Bronze Valves.

Illustrated above:
No. 575 Union Bonnet Globe Valve with renewable composition disc and slip-on disc holder. 200 lbs. S. W. P.
No. 400 Gate Valve, heavy pattern rising stem. 150 lbs. S. W. P.

Illustrated below:
No. 350 Thermostatic Trap.
No. 209 Lever handle, graduated Radiator Valve.

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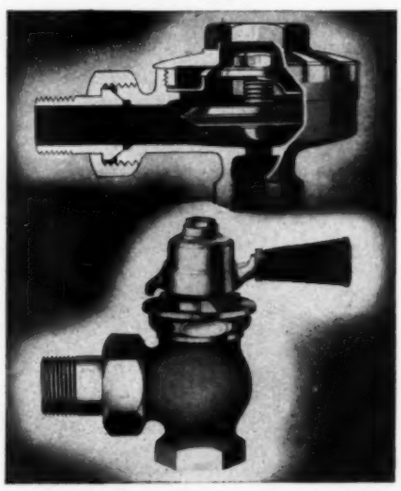
FOR HEATING SYSTEM MODERNIZATION

MILVACO Specialized Modernization Units restore heating system efficiency and cut heating costs. There is a MILVACO Modernization Unit to fit every popular make of radiator valve and thermostatic trap in use today.



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● To aim is never enough. Only achievement makes the aim worthwhile. In industrial competition, to aim and achieve a little better than others . . . it is the story of the better mousetrap . . . will bring buyers to any merchant's door.

● In Air-conditioning . . . just this one thing makes Friez Products stand out. To do a little better, to add a little freshness, to devise and make products suited definitely for the development of Air Conditioning . . . that has been our aim. Our friends . . . and they are multiplying every day . . . tell us that we may well speak of it as an aim achieved.

● FRIEZ HUMIDISTATS give a "hair-trigger," unfailing control that has actually solved the humidity control problem. Some have estimated that nearly eighty percent of all installations with humidity control employ the famous Friez Human Hair element.

● FRIEZ PORTABLE RECORDERS (now in improved models) are practically standard for records of Temperature and Humidity and operation periods. Their testimony is widely accepted in arbitration. They are not all-purpose, "Jack at all trades" instruments . . . but are specially designed as tools for Air-conditioning Engineers.

● FRIEZ WINDOWSTATS so control Humidity in winter Heating that there can be no condensation on the window-pane. It is a sure-fire, inexpensive, simple method of driving the white ghost of frosting from the glazed window. Air-conditioning men were haunted by it, until the Friez Windowstat laid the ghost.

● FRIEZ COMFORTROL . . . the only single instrument that will deliver effective temperature . . . that compound of temperature and humidity that determines Human Comfort. The aim of Air-conditioning, again is signalized as an achievement of Friez.

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and the apparatus and procedure in coal testing described. Functions of the stoker, flow of coal from hopper to retort, effect of heat on coal, smoke, ash and clinker, and over-all stoker operation are among the subjects covered.

The authors' analysis shows that the two principal characteristics of a coal that determine its performance on small stokers are its caking and coking tendencies and its size range, and that these are, for many and probably for most bituminous coals, closely related. Conditions are favorable to coke formation, as is shown by the fact that coals normally considered free burning form coke in the stoker fuel bed. Practically all coals, therefore, form coke trees, but even rather strong coke formations cause little or no real difficulty in properly designed combustion chambers. They state that the caking and coking tendencies may generally be reduced by adjustment of the size range which may include either reduction of the top size or removal of the fines from the coal, or both, but with many coals this is entirely unnecessary.

It is pointed out that stokers are in a continual process of development, and while originally it was thought that only the truly free-burning coals could be used, now a wide range of caking and coking coals is burned successfully.

Advice for Sinus Sufferers

Don't sleep in a freezing cold bedroom or sleeping porch, particularly if you are one of the several million people now expecting the seasonal onslaught of sinus trouble, advises a health bulletin just issued by Northwestern National Life Insurance Co.

A bedroom temperature of 68 F is cool enough for health, if proper humidity is maintained. If no humidifying device is used, the room should be kept a few degrees cooler. But with the blood circulation slowed by sleep, the bulletin warns, the nasal passages are poorly protected against bitter cold, which frequently starts irritation in the sinuses.

Air conditioning of homes and offices is one of the best defenses against sinus trouble, according to the bulletin, which warns that prevention is much simpler than cure.

Dehumidification of Air with Coils

The paper "Dehumidification of Air with Coils," by William Goodman, Trane Co., La Crosse, Wis., presented at the spring meeting of the *American Society of Refrigerating Engineers* is published (with the discussion) in the October, 1936, issue of the *Journal* of the *A. S. R. E.*, 37 W. 39th St., New York City. It is some 50 pages in length.

The action of air in contact with cold wetted surfaces is analyzed mathematically. A method is presented for computing the portion of the area of a cold surface which remains dry and the area which will be covered with a film of moisture condensed from the air. A semi-graphical method of drawing the curve on the psychrometric chart, representing the relation between the dry and wet bulb temperature of the air as it flows over a cold wetted surface, is given. Formulas are developed for calculating the required area to cool and dehumidify air. The application of the method is verified experimentally for the condition where the temperature of the refrigerant remains constant.

Directory of Laboratories

The National Bureau of Standards, Washington, D. C., has issued a third revised edition of the Directory of Commercial Testing and College Research Laboratories, replacing Miscellaneous Publication M90, which has been out of print for the past two years. The new directory lists commercial laboratories throughout the country with information concerning the commodities which they are prepared to test. There is presented also a list of college laboratories which are used not only for instruction purposes but also for research.

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For economical temperature control, be sure that "Jointite" Corkboard and Moulded Cork Pipe Covering are in the specifications. These products are fabricated by the Mundet process from 100% pure Cork—nature's own insulator—and offer low cost, permanent protection. Let us show you "Jointite's" performance record . . . its best reason for being preferred.

Machinery vibration is effectively isolated with Mundet Natural Cork Mats. Ask us for details.

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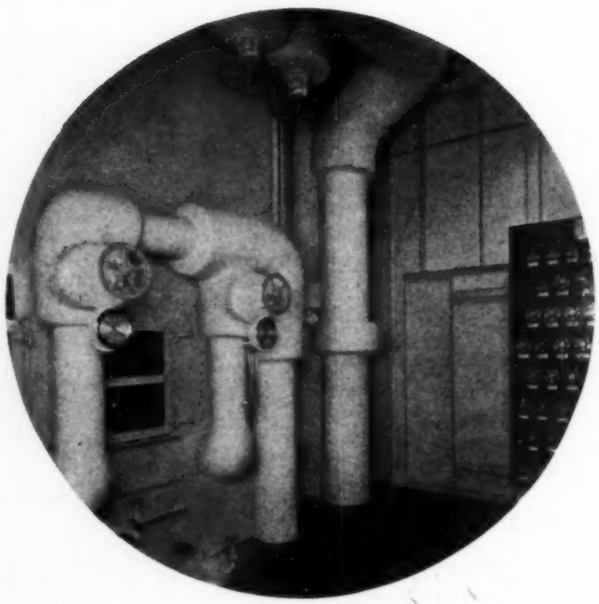

Illustration shows "Jointite" Moulded Cork Pipe Covering with canvas finish.

ALCO

YEARS ago, the founders of Alco Valve Co., Inc., combined an idea with knowledge and experience, and produced an automatic liquid refrigerant control valve far superior to anything then in use.

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From that day to this, Alco Valve Co., Inc., has been a pioneer in the development of accurate refrigerant control devices and has continued to combine practical ideas and technical skill with an ever increasing knowledge of refrigerants and their control. The result is that Alco Valves are favorably known wherever refrigerants are controlled.

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The knowledge gained through the years is yours for the asking. Alco engineers are at your service. Let them show you how to obtain highest efficiency through the proper application of accurate control devices.

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See the Alco Exhibit and talk to Alco Engineers at the R. S. E. S. Convention, Memphis, Tennessee, November 11, 12, 13, 1936; or write, wire or phone the factory or any representative at any time.

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has resulted in
Quieter Air Conditioner Motors

WAGNER has furnished motors for air conditioning equipment for many years and has continuously improved motors for this purpose. Among the outstanding features of Wagner motors are: *(1)* QUIET OPERATION, *(2)* special operating characteristics to meet this exacting service, *(3)* long life, and *(4)* attractive appearance. As a result of Wagner's many years of experience in building motors for air conditioning equipment, Wagner motors are leaders in this field.

A few of the points of superiority of Wagner squirrel-cage motors are:

1. Rotor is of the cast-aluminum type, with bars, end-rings and blowers cast integrally, effecting a one-piece rotor exceptionally sturdy and long-lived. Skewed closed rotor slots minimize magnetic pulsations across the air gap and produce uniform starting torque at different positions of the rotor.

2. The frame and end-plates are strong and rigid, and accurately machined—assuring permanent alignment of bearings and uniform air gap, two essentials for quiet operation.

3. Blowers furnished on both ends of the rotor and many large openings in the stator frame insure thoro and unrestricted ventilation.

4. Stator windings are given a superior winding treatment which provides an insulating surface that is oil and moisture resisting and can be easily cleaned.

5. Stator and rotor laminations are punched from annealed, non-aging, high-grade electric sheet-steel selected for its magnetic properties.

Many other features of Wagner motors are worth investigating. Write today for Bulletin 182 which describes the Wagner motors that are Second-to-None for air conditioning.

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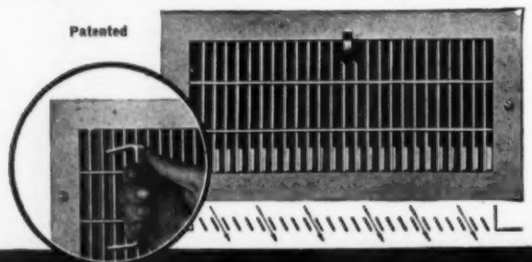

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Future of Air Conditioning

Willis H. Carrier, Chairman of the Board, Carrier Corp., addressed the annual National Business Conference at Wellesley Hills, Mass., October 5, on the future of the air conditioning industry. Copies of his paper have been made available by Carrier Corp., 850 Frelinghuysen Ave., Newark, N. J.

The two industries that seem to be leading the way out of the depression, said Mr. Carrier, are aviation and air conditioning, both relating (perhaps significantly) to man's conquest of the air. He remarked on the early history of air conditioning and said that there were a few installations for human comfort in 1908, but that the considerable development started in 1916 when the movie theaters began experimentation. The next field to appreciate the commercial possibilities was the department store, and while theaters, department stores and restaurants have played an important part, he believed the greatest impetus to public acceptance came through the wholesale adoption of railroad air conditioning. He pointed out that in the last few years installations have been largely commercial as distinguished from industrial or personal, although the number of small commercial and personal installations has greatly increased recently.

Advantages of air conditioning were briefly summarized, and Mr. Carrier estimated that in 1930 air conditioning was making a net annual saving of $16,000,000 to industry in the United States, largely as a result of production economies. He gave examples of savings, as well as the business advantages of commercial installations.

In speaking of the rate of growth of air conditioning, Mr. Carrier referred to a paper he presented in 1932 before the *American Institute of Electrical Engineers.* (See December, 1932, H. P. & A. C.). From statistics now available that prediction for 1933 was almost exactly correct, but for 1934 sales were $10,000,000 more than estimated, and for 1936 they were more than double the 1932 estimate. He said that it now seems safe to predict that the volume in any subsequent year will be at least double the volume projected in 1932, and the probabilities are that it will be even greater because indications are that for some time (at least until the peak of sales has been reached) business may be expected to double about once every three years instead of every four years. Much depends upon what happens to the home market within the next few years, he said.

We may conclude, he said, that at the end of this year there will be between 500,000 and 600,000 connected hp for air conditioning in the United States, and apparently this is doubling every three years. This will mean a connected load of approximately 4,000,000 hp at the end of 1945, which is as great as predicted in 1932 for 1951. The probable annual power cost will then be around $80,000,000, depending upon the average power rate in force at that time. Total outlay for air conditioning in 1945, including service and maintenance of existing plants, may be estimated around a half billion dollars.

In his remarks on power and water supply, he said that in addition to the power load required to provide cooling effect, where fans, pumps and other auxiliaries are required to be in operation, the total annual power cost is about double the cost of operating the refrigerating equipment alone. He pointed out that the user will pay to the power company annually from $20 to $25 per hp of connected load so that in the end, considering the life of the equipment, the power company will receive a greater return from air conditioning than the vendors of the equipment. As to water supply, unless other means of cooling are provided, the use of water by air conditioning plants will shortly become so tremendous, no city will be able to provide sufficient water supply. He pointed out the applications of water conserving equipment.

Mr. Carrier concluded by saying that one common misconception is that radical improvements will greatly lower owning and operating costs.

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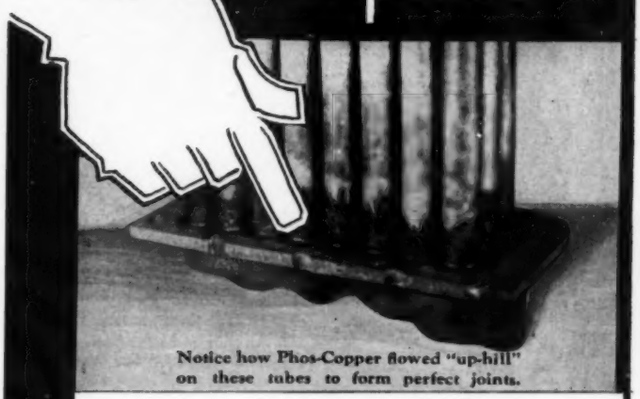

Notice how Phos-Copper flowed "up-hill" on these tubes to form perfect joints.

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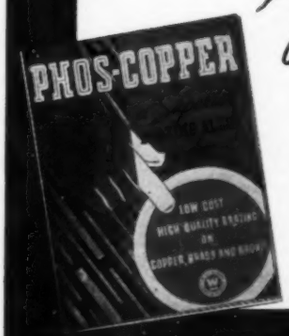
Try it on any type of copper or copper alloy brazing . . . for butt, lap or sleeve joints. Compare it with *any* brazing alloy for ease of application, strength and ductility, for flow through tight joints, and fluxing requirements . . . and our prediction is you will standardize on Phos-Copper! J 20111



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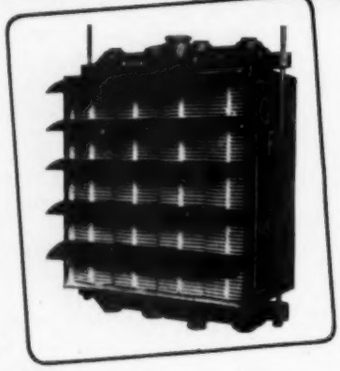

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Conventions and Expositions

National Association of Practical Refrigerating Engineers: Annual meeting and exhibit, November 10-13, Drake Hotel, Chicago, Ill. Secretary, Emerson Brandt, 228 N. La Salle St., Chicago, Ill.

Refrigeration Service Engineers' Society: Annual convention, November 11-13, Hotel Gayoso, Memphis, Tenn. National Secretary, H. T. McDermott, 433 N. Waller Ave., Chicago, Ill.

International Acetylene Association: Annual convention, November 18-20, Jefferson Hotel, St. Louis, Mo. Headquarters Office, 30 E. 42nd St., New York, N. Y.

Twelfth National Exposition of Power and Mechanical Engineering: November 30-December 5, Grand Central Palace, New York, N. Y. Manager, Charles F. Roth, Grand Central Palace, New York, N. Y.

American Society of Mechanical Engineers: Annual meeting, November 30-December 5, New York, N. Y. Secretary, C. E. Davies, 29 W. 39th St., New York, N. Y.

American Society of Refrigerating Engineers: Annual meeting, December 2-4, New York, N. Y. Secretary, D. L. Fiske, 37 W. 39th St., New York, N. Y.

Welding Conference: 12th annual conference and exhibit on welding, December 10-11, Purdue University, Lafayette, Ind. J. D. Hoffman, Director, Department of Practical Mechanics, Purdue University.

National Warm Air Heating and Air Conditioning Association: Winter meeting, December 15-17, Stevens Hotel, Chicago, Ill. Managing Director, Allen W. Williams, 50 W. Broad St., Columbus, Ohio.

American Society of Heating and Ventilating Engineers: Annual meeting, January 25-27, Hotel Statler, St. Louis, Mo. Secretary, A. V. Hutchinson, 51 Madison Ave., New York, N. Y.

Book Reviews

Kent's Mechanical Engineers' Handbook

"Kent's Mechanical Engineers' Handbook," by R. T. Kent, Editor-in-Chief, with the collaboration of a staff of specialists. Volume II (Power) of the Wiley Engineering Handbook Series. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y. 11th edition, 1254 pp., 5⅝ x 8⅝ in. Price, $5.00.

A revolutionary change has been made in the set-up of this edition of Kent's well-known handbook for mechanical engineers. In line with the new plan of publication of the Wiley handbooks in mechanical and electrical engineering, Kent's has been divided into two sections, the present volume being subtitled "Power". The second will be devoted to design and shop practice, and will appear next spring.

Seventeen sections and a complete index comprise the book. The sections are titled: Air; Water; Heat; Combustion and Fuels: Steam; The Steam Boiler; The Steam Engine; The Steam Turbine; Condensing and Cooling Equipment; Refrigeration and Ice Making; Heating, Ventilating, and Air Conditioning; Internal Combustion Engines; Gas Producers; Transporta-

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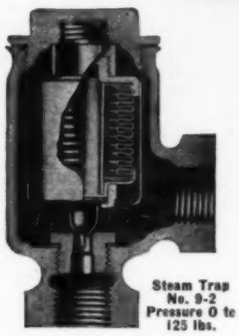
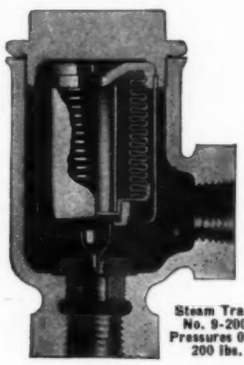


Steam Trap No. 9-2 Pressure 0 to 125 lbs.



Steam Trap No. 9-200 Pressures 0 to 200 lbs.

You can't obtain efficient use of steam nor economical use of fuel, unless you remove the air and discharge the condensate from your steam lines and coils as fast as they appear. For air and water fight heat.

By equipping each piece of equipment with a Sarco Steam Trap, air will be vented and condensation discharged as soon as formed, assuring a steady flow of hot, dry steam.

They are inexpensive enough to justify individual trapping at every point where condensate forms. There can be no air bound or water logged coils — no heat wasted from long lines to centrally located traps.

SARCO STEAM TRAPS

take up no valuable space, but screw into the line like a fitting.

Sarco Traps are effecting large fuel savings in plants throughout the country. Perhaps they would do likewise for you.

Prove this out for yourself at our expense. We'll send one free for a month's trial. No proof, no charge. But thousands have been sold on that test alone.

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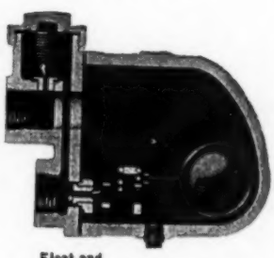

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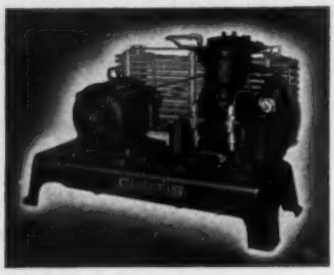

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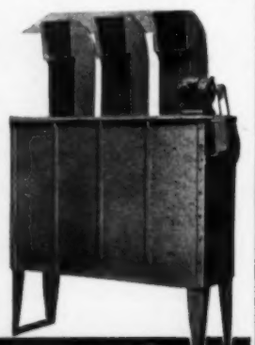
There are ten floor Models varying from 120,000 to 800,000 B.t.u. capacities.



Offer the ideal type of heat for factories, warehouses, etc., as well as lower heating costs. From the complete catalog line of Young units you can select a unit to meet your exacting requirements.

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YOUNG RADIATOR COMPANY
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tion; Electric Power; Power Test Codes; and Mathematical Tables. Among the 28 collaborators are Louis A. Harding (air conditioning, heating, ventilating, refrigeration); Robert K. Behr (flow of steam, steam boilers); A. G. Christie (thermodynamics); Francis E. Finch (drying); V. deP. Gerbereux (pumps); W. J. King (heat transmission); A. S. McCormick (stresses in pipe lines); Percy Nicholls (heat insulation); Robert Peele (compressed air); Harry F. Tapp (liquid fuels).

The book is designed for practicality and convenience, and the new format has permitted the use of large, clear type, illustrations, and diagrams.

Arc Welding Handbook

"Procedure Handbook of Arc Welding Design and Practice," published by The Lincoln Electric Co., 12818 Coit Road, Cleveland, Ohio. 4th edition, 819 pp., 5¾ x 9 in. Price, $1.50 (in U. S.), $2.00 (outside U. S.).

Over 200 new pages of arc welding data and nearly 300 new illustrations are included in the recently issued edition of this arc welding handbook. The material which has been added includes information on characteristics of the welding generator, selection of type of joint, insurance of fusion welded vessels, welding codes, arc cutting, polarity of welding current, horizontal welds, sheet metal welding, effect of electrode size on welding cost, methods of testing weld metals, 4-6 chrome steel, monel metal, principles of surfacing by welding, and other subjects.

The eight sections into which this book is divided are: Welding Methods and Equipment; Technique of Welding; Procedure, Speeds and Costs for Welding Mild Steel; Structure and Properties of Weld Metal; Weldability of Metals; Designing for Arc Welded Steel Construction of Machinery; Designing for Arc Welded Structures; and Typical Applications of Arc Welding in Manufacturing, Construction and Maintenance (including furnaces and heating boilers; piping; oil, gas and water pipe lines; tanks; etc.). An advertising section is appended.

Statement of Ownership and Management of "Heating, Piping and Air Conditioning" for October 1, 1936

The following is a statement of ownership, management, etc., as required by the Act of Congress of March 3, 1933, of "Heating, Piping and Air Conditioning," published monthly at Chicago, Ill., for October 1, 1936:

State of Illinois, County of Cook, ss: Before me, a Notary Public in and for the State and county aforesaid, personally appeared F. P. Keeney, who, having been duly sworn according to law, deposes and says that he is the business manager of "Heating, Piping and Air Conditioning," and that the following is, to the best of his knowledge and belief, a true statement of the ownership and management of the aforesaid publication, for the date shown in the above caption, required by the Act of August 24, 1912, embodied in Section 411, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business manager are:

Publisher, Keeney Publishing Company, Chicago, Illinois.
Editor, C. E. Price, Chicago, Illinois.
Managing Editor, C. M. Burnam, Jr., Chicago, Illinois.
Business Manager, F. P. Keeney, Chicago, Illinois.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Keeney Publishing Company, 6 North Michigan Ave., Chicago, Illinois. Stockholders: F. P. Keeney, Chicago; W. J. Osborn, Fairfield, Conn.; R. Payne Wettstein, Chicago; Chas. E. Price, Chicago; Robert A. Jack, Cleveland Heights, Ohio.

3. That the known bondholders, mortgagees and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages or other securities are: None.

4. That the two paragraphs next above, giving the names of the owners, stockholders and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company, but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting is given; also that the said two paragraphs contain statements embracing affiant's full knowledge, and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

F. P. Keeney,
Business Manager.

Sworn to and subscribed before me this 1st day of October, 1936.
Grace E. Waymire.
[My commission expires Feb. 10, 1938.]
Notary Public.
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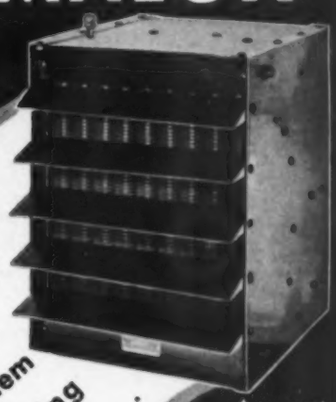

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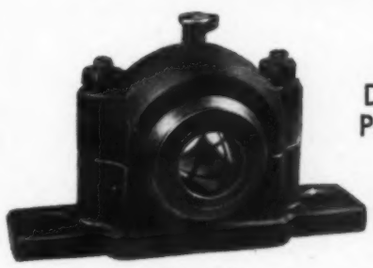

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Handbook of Chemistry and Physics

"The Handbook of Chemistry and Physics," Chas. D. Hodgman, Editor-in-Chief. Published by the Chemical Rubber Publishing Co., 1900 W. 112th St., Cleveland, Ohio. 21st edition, 2028 pp., 4½ x 6¾ in. Price, $6.00.

The new edition of this standard work represents an increase of over 175 pages of new composition entailed by the complete revision of several important tables.

The handbook is divided into five sections of approximately equal length, as follows: Mathematical Tables; Properties and Physical Constants; General Chemical Tables; Heat, Hygrometry, Sound, Electricity, and Light; Quantities and Units—Miscellaneous Tables.

New features include improvements in the mathematical tables, an enlarged photographic section, a special table for convenience in the reduction of gas volume to standard conditions, new material on statistics, and other revisions and additions.

Recent Trade Literature

For your convenience in obtaining copies of bulletins, see coupon on page 142.

No. 2158—ABSORPTION REFRIGERATING MACHINES: Carbondale Machine Corp., Worthington Ave., Harrison, N. J. 16 p. bulletin on absorption refrigerating machines, explaining operating principle and giving information on three types of units—atmospheric, double-pipe and tubular. Operating cycle explained, construction of the parts of the machines described and illustrated, and general data required for selection of a machine outlined.

No. 2159—ACCESSORIES: American Radiator Co., 40 W. 40th St., New York, N. Y. 4 p. bulletin on "Ideal-Arco" heating accessories, including gauges, thermometers, expansion tanks and trimmings, floor and ceiling plates, boiler cleanser and seal, and boiler furnace cleaner.

No. 2160—AIR CONDITIONING: Carrier Corp., 850 Frelinghuysen Ave., Newark, N. J. (a) 16 p. bulletin on air conditioning, refrigeration and space heating equipment, including various types of units, large central plant systems, surface type dehumidifiers, air distributing systems, unit heaters, product cooling and storage equipment, refrigerating machines, and evaporative condensers. (b) 4 p. bulletin on air conditioning with the "Weathermaster," year 'round conditioning unit for individual rooms adaptable to hotels, offices, apartments and other buildings where air conditioning must be provided to meet requirements of separate rooms.

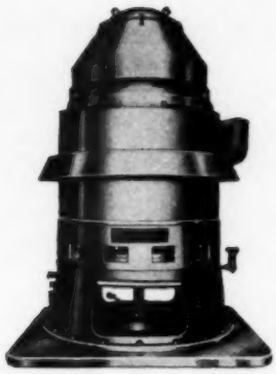
No. 2161—AIR CONDITIONING: Fedders Mfg. Co., 57 Tonawanda St., Buffalo, N. Y. Issue of "Fedders News," Vol. 3, No. 10, including discussion of rational method of rating water type air conditioning surface.

No. 2162—ALLOYS: Climax Molybdenum Co., 500 Fifth Ave., New York, N. Y. Issue of "The Moly Matrix," Vol. 3, No. 10, including article on molybdenum irons and steels for insuring dependable pump construction.

No. 2163—COMPRESSED AIR: Worthington Pump & Machinery Corp., Harrison, N. J. 4 p. bulletin "Compressed Air at Lower Cost," briefly describing "feather valve" compressors.

No. 2164—CONTROLLERS: The Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., Wayne & Roberts Aves., Philadelphia, Pa. 32 p. catalog of air operated controllers for temperature, pressure, flow and liquid level, explaining in non-technical language principle of operation and including helpful diagrams illustrating simplified construction of the equipment.

No. 2165—CONTROLS: Automatic Temperature Control Co., Inc., 34 E. Logan St., Philadelphia, Pa. 8 p. bulletin on industrial controls for regulating temperature, time, level, flow



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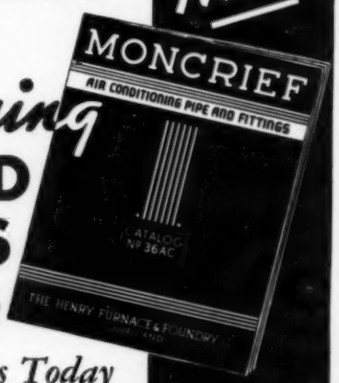

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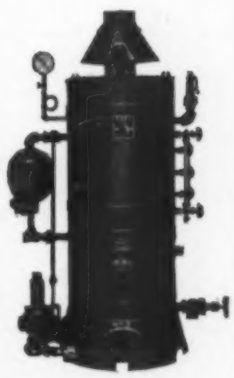

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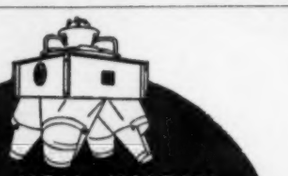

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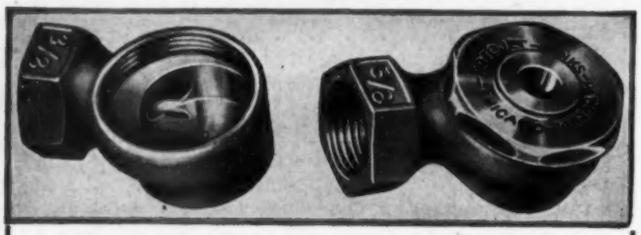

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and pressure, describing this company's "ATC" line, fundamentals in selection of time controls, fundamentals of controlling temperature, and illustrating and describing the equipment.

No. 2166—CONTROLS: Penn Electric Switch Co., 2000 E. Walnut St., Des Moines, Ia. (a) 4 p. bulletin on stoker combustion controls, describing features and performance. (b) 4 p. bulletin on limit switches for hot water, steam and vapor heating applications.

No. 2167—CONVECTORS: American Radiator Co., 40 W. 40th St., New York, N. Y. 4 p. bulletin describing "Arco" radiant convector, new concealed radiator designed to give correct combination of convected warmth with radiant heat.

No. 2168—CONVECTORS: National Radiator Corp., 221 Central Ave., Johnstown, Pa. 36 p. catalog on "Aero" cast iron convector giving information on this company's line of convectors, selection, piping connections, dimensions, enclosures, front panels, construction details, ratings, performance data, and special applications.

No. 2169—COOLING TOWER EQUIPMENT: Binks Mfg. Co., 3106 Carroll Ave., Chicago, Ill. 8 p. bulletin on cooling equipment for use with Westinghouse type CLS condensing units, giving engineering data on atmospheric spray cooling towers, indoor forced draft towers, induced draft cooling towers, and featuring selection tables.

No. 2170—COPPER FITTINGS: American Radiator Co., 40 W. 40th St., New York, N. Y. 8 p. bulletin on "Arco Full Flow" wrought copper fittings for heating, plumbing, air conditioning, refrigeration, and industrial process applications, and marine, utility and transportation usages. Illustrations and descriptions of the fittings are given, instructions for installing are presented in a series of photographs, and roughing-in dimensions are tabulated. Solder, soldering paste and copper pipe are described briefly.

No. 2171—ECONOMIZERS: York Ice Machinery Corp., New York, Pa. 8 p. bulletin on "Economizer," self-contained combination forced draft cooling tower and refrigerant condenser, designed for either indoor or outdoor installation, describing construction, giving specifications and presenting table of savings in comfort air conditioning installations through use of this water conserving equipment.

No. 2172—FURNACE CONSTRUCTIONS: Geo. P. Reintjes Co., 2517 Jefferson, Kansas City, Mo. 12 p. bulletin on advantages of this company's furnace constructions, describing standardized sectionally supported furnace walls and their features.

No. 2173—HEATING EQUIPMENT: The Borg Warner Service Parts Co., 2100 Indiana Ave., Chicago, Ill. Catalog of parts and accessories used in automatic heating and winter air conditioning distributed by this company.

No. 2174—HEATING EQUIPMENT: National Radiator Corp., 221 Central Ave., Johnstown, Pa. 28 p. pocket size booklet entitled "The National Line," briefly describing boilers of several types, radiation, cast iron convectors, enclosures, unit heaters and other products.

No. 2175—ICE SKATING RINKS: Frick Co., Waynesboro, Pa. 8 p. bulletin on equipment for ice skating rinks, illustrating a number of installations.

No. 2176—LUBRICATION: E. F. Houghton & Co., 240 W. Somerset St., Philadelphia, Pa. 32 p. lubrication edition of "Research Illustrated," including a summary of the development of the lubrication industry, an article on the necessity of lubrication, one on the lubrication of gears, and other pertinent data.

No. 2177—MECHANICAL TUBING: The Timken Steel & Tube Co., Canton, O. Leaflet briefly describing mechanical tubing and how it is "quality controlled" from steel furnaces to finished tubing. Produced in sizes ranging from ½ to 10 in. O. D., and up to 1½ in. wall thickness.

No. 2178—MERCURY SWITCHES: Durakool, Inc., 1010 N. Main St., Elkhart, Ind. 6 p. bulletin on mercury switches illustrating and describing features and advantages, and giving dimensions and selection tables.

No. 2179—PUMPS: The Deming Co., Salem, O. (a) 8 p. bulletin on single stage, split case, centrifugal pumps, presenting

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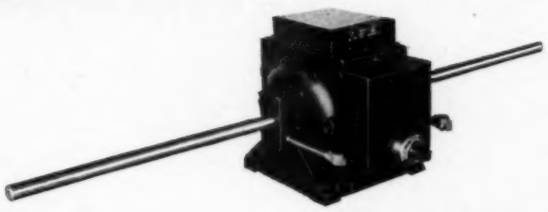

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specifications, describing features of construction and showing dimensions. (b) 16 p. bulletin on water lubricated deep well turbine pumps, describing and illustrating features of construction, listing and illustrating many installations, and including information on automatic pressure systems with deep well turbines.

No. 2180—PUMPS: Ingersoll-Rand Co., 11 Broadway, New York, N. Y. 16 p. bulletin on coupled pumps in capacities from 150 to 5,000 gpm, against heads between 20 and 250 ft, designed for handling nearly all liquids. Constructional features are described in detail and performance tables, dimensions and pertinent data are given.

No. 2181—PUMPS: Worthington Pump & Machinery Corp., Harrison, N. J. 4 p. bulletin on centrifugal pumps arranged for automatic priming.

No. 2182—REFRIGERANTS: The R. & H. Chemicals Dept., E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. Issue of "Artic Service News," presenting large chart showing pressure-temperature relationships of "Artic" (methyl chloride) and other refrigerants.

No. 2183—STEAM TRAPS: Armstrong Machine Works, 874 Maple St., Three Rivers, Mich. 8 p. bulletin on steam traps, designed as a guide for operators and managers of hospitals, hotels, restaurants and other public institutions, discussing individual traps for each steam-using unit, and applications to laundry equipment, hot water heaters, sterilizers and kitchen equipment.

No. 2184—STOKERS: Fairbanks, Morse & Co., 900 S. Wabash Ave., Chicago, Ill. 24 p. bulletin on automatic coal burners, covering stoker selection and use and discussing advantages and features of this company's stokers for industrial, commercial and domestic applications.

No. 2185—STOKERS: Link-Belt Co., 307 N. Michigan Ave., Chicago, Ill. 28 p. booklet on automatic coal stokers for industrial and commercial use in capacities up to 300 hp, discussing construction and features of this company's equipment and presenting data on various installations to show the self-liquidating nature of investments in stokers.

No. 2186—THAWING WATER PIPES: Hobart Bros. Co., Troy, O. Book on thawing frozen water pipes, with drawings and diagrams of various hook-ups covering actual cases, including nature of the job, time required, length of pipe to be opened up, size and kind of pipe, costs, etc.

No. 2187—UNIT HEATERS: Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago, Ill. 48 p. catalog on unit heating, presenting information on features of this company's equipment, motors and motor speeds, specification form, finishes available, performance data, capacity constants, dimensions and weights, and giving information on estimating heat load, approved piping methods, recirculating ducts, etc. Advantages of electric type unit heaters are described and technical data are given.

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Please ask the manufacturer to send me more information about the equipment mentioned under the following reference numbers in "Equipment Developments" and "Recent Trade Literature." (Circle the numbers in which you are interested):

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1101	1102	1103	1104	1105	1106	1107
1108	1109	1110	1111	1112	1113	1114
1115	1116	1117	1118	1119	1120	1121
1122	1123					
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2183	2184	2185	2186	2187	2188a	2188b
2189	2190	2191	2192	2193		

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No. 2188—V-BELT DRIVES: Rockwood Mfg. Co., 1801-2001 English Ave., Indianapolis, Ind. (a) 12 p. data book on single groove V-belt drives, presenting data to simplify selection and discussing applications and advantages. (b) 32 p. data book on multiple groove V-belt drives, giving information on how to select such drives. Complete range from fractional to 500 hp is covered by these two books.

No. 2189—VIBRATION ISOLATION: The Korfund Co., Inc., 48-15 32nd Pl., Long Island City, N. Y. Issue of "Isolation," Vol. 5, No. 1, including article on elementary considerations of vibration control by S. Rosenzweig, president and consulting engineer, The Korfund Co., Inc., an article on cork as a natural isolating medium, and describing natural cork plates, "Seismo-Dampers" and vibration isolation by means of steel springs.

No. 2190—WATER PIPE SIZES: Bridgeport Brass Co., E. Main St., Bridgeport, Conn. 48 p. revised edition of "Water Pipe Sizes for Plumbing Fixtures, Branches, Risers and Mains," by Walter S. Timmis, including tables on pipe sizes and carrying capacities, and giving information on "Plumrite" brass and copper pipe and its uses, and facts about copper water tubing with solder type and compression fittings.

No. 2191—WELDING: Hobart Bros. Co., Troy, O. 24 p. booklet on easier, more profitable arc welding with new 40 volt "simplified" welder, illustrating and describing features of the welder, auxiliary power generators and welding accessories, and welding electrodes.

No. 2192—WELDING: The Lincoln Electric Co., 12818 Coit Rd., Cleveland, O. 20 p. booklet "The New Arc Welding Technique," describing "Shield-Arc SAE" welder with dual continuous control, and showing how the method of control varies penetration of any welding current, and improves welding technique. Other features of the welder are described in detail.

No. 2193: WELDING: Universal Power Corp., 1719 Clarkstone Rd., Cleveland, O. 8 p. bulletin on arc welding accessories, including helmets, face shields, goggles, brushes, holders, cable, gloves, aprons, leggings, etc.

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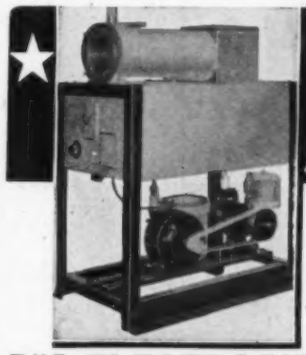

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